OFF-DUTY ACTIVITY EQUIPMENT AND FACILITIES FOR ADVANCED SPACECRAFT

(PRELIMINARY DESIGN)

Prepared By:
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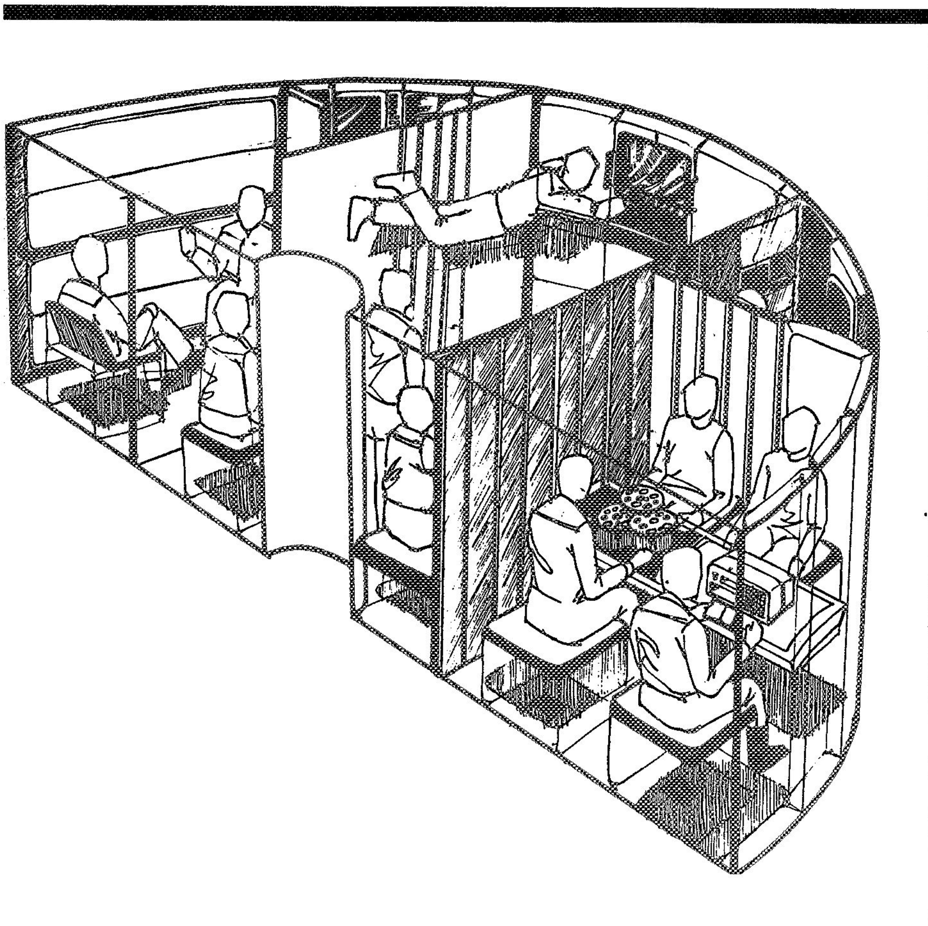
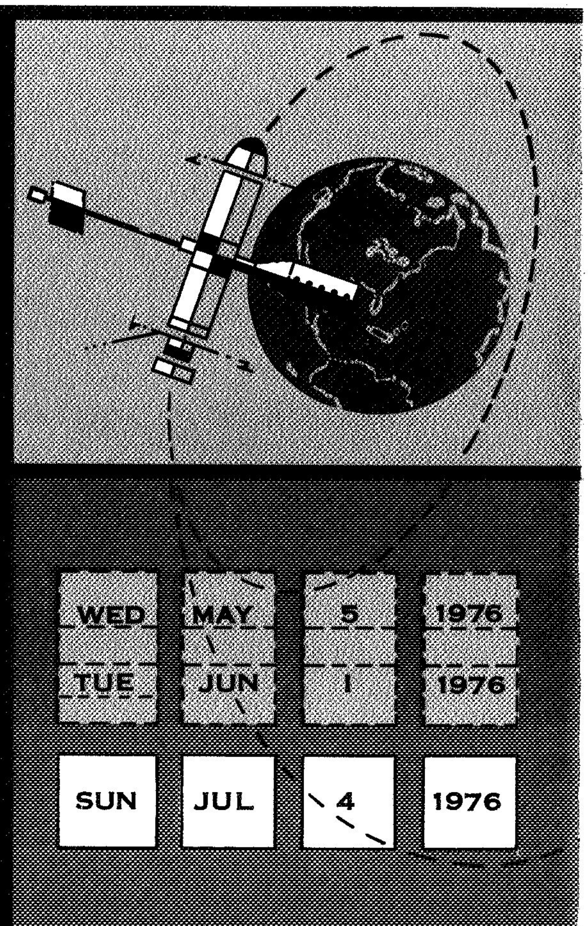
Prepared For: National Aeronautics and Space Administration
Manned Spacecraft Center · Houston, Texas





March 1970 · Technical Monitor: Joe E. Reed · Contract NAS 9-9338

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CHAPTER I

SUMMARY AND RECOMMENDATIONS

INTRODUCTION

This study establishes the preliminary design requirements for off-duty equipment and facilities for space stations and space bases. Eberhard (1970) found that inadequate attention had been given to the off-duty time period for long duration missions. He also found that lack of sufficient planning in the off-duty time area could lead to significant crew morale problems.

In the previous space missions, the time available for off-duty activities had been extremely limited. However, the advent of larger spacecraft and longer duration missions will be accompanied by increasing amounts of off-duty time. To reduce the boredom and rigor of confinement, it becomes essential to design an adequate off-duty facility.

SCOPE AND OBJECTIVES

This study was undertaken to develop preliminary designs for off-duty activity equipment and facilities for space stations and space bases. The general objective was to identify feasible off-duty activities, equipment, and facilities to support anticipated missions in such vehicles. In more detail, the objectives of this study were to:

- Identify off-duty activities performed by confined individuals.

- Identify differences in off-duty activities due to crew size and composition.

- Suggest means to facilitate performance of biomedically critical exercise.

- Create recreational activities to relieve monotony and boredom.

- Identify off-duty activities compatible with spacecraft constraints.

- Identify off-duty equipment in accordance with spacecraft constraints.

- Design off-duty facilities in accordance with space station and space base constraints.

RELATIONSHIP TO OTHER NASA EFFORTS

This report builds upon and extends earlier research supported by NASA, particularly that conducted by Landis, et al (1969), and by Eberhard (1967a, 1967b, 1967c; 1970). Although the present study was directed specifically to the preliminary design of off-duty facilities for the space station and space base, the findings are applicable to the design of other areas within these spacecraft. In addition, the off-duty activity and equipment concepts should be considered in the Apollo Applications Program.

APPROACH

A four step approach was employed to develop preliminary design for the recreational facilities. These steps were:

- Identify assumptions and constraints for the space station and space base (Table 1 and Chapter II);

- Identify activities desired by crewmen for missions of three to six months duration (Chapter III);

- Identify equipment for the desired activities which is compatible with spacecraft constraints (Chapter IV);

- Design recreation facility layouts for the space station (Figure 1 and Chapter V), and space base (Figure 2 and Chapter V).

In addition, research and development recommendations relating to off-duty activities, equipment, and facilities were developed (Table 2).

SIGNIFICANT FINDINGS AND DATA GENERATED

Findings and data generated in this study are summarized below in accordance with the four areas of the approach.

Establishment of Spacecraft and Mission Assumptions and Constraints

The assumptions basic to the design of the facilities are presented in Table 1. The rationale behind the assumptions is presented in Chapter II. The assumptions were developed from the request for proposal, NASA publications and discussions with NASA personnel.

TABLE 1

ASSUMPTIONS AND CONSTRAINTS

	Space Station	Space Base
Crew Size	6 to 12 men	50 to 100 men
Crew Composition	Professional	Technical and Professional
Facility*	Half of a 22 foot cylinder 78" in height	Two halves of a 33 foot cylinder 78" in height
Facility Area per Crew Member	30.6 to 15.3 sq. feet	16.8 to 8.4 sq. feet
Gravity	Zero gravity	0.3 gravity
Time Frame (approximate)	1975	Late 1970's.
Mission Length	3 to 6 months	3 to 6 months
Off-duty Time (per day)	5 hours	5 hours
Resupply Interval	None	Approximately every 30 days.
Completion Time for Systems Integration	1973	1976
Need for Stowability and Deployability	One man	One man + **

* Equipment designs exceeding these constraints were also considered in anticipation of possible changes in allotted space.

** Stowability and deployability of equipment by one man was considered desirable but was a less stringent constraint on the space base.

Analyses performed in establishing the constraints showed:

- The square footage per crew member available for leisure activities in the space base is only half that available in the space station.

- The available floor area for the space base recreation facility is inadequate for the full crew to simultaneously perform activities in the facilities.

Off-Duty Activity Considerations

Surveys of off-duty activities were compared to activities actually performed by confined personnel. Those activities likely to be engaged in and the predicted frequency of participation for expected professional crew members are:

Daily

Watching TV shows
Listening to popular music
Bull sessions

A Few Times a Week

Reading newspapers (magazines)
Watching news, sports, weather reports
Doing nothing
Physical exercise
Eating snacks

Weekly

Studying
Viewing space
Listening to classical music
Job related activities
Watching sports shows
Personal (family) communication
Playing sports
Watching movies on TV

A Few Times a Month

Reading fiction
Watching educational shows
Reading technical books
Watching travelogues
Watching comedy
Being alone
Listening to folk music

Monthly	Less Than Once a Month
Playing cards	Watching drama
Personal (friends) communication	Watching westerns
Playing chess/checkers	Building something
Personal writing	Reading religious materials
Watching detective shows	Religious activities
Listening to jazz music	Playing musical instruments
Technical writing	Photography
Reading biographies	Personal communication (professional)
Repairing something	Playing board games

In addition to professional personnel, there will also be technical support personnel on the space base. Findings relative to these two groups are:

- Professional and technical support personnel differ in certain activity preferences and in content preferences within activities.

- Group preference differences in music are particularly important. Professionals tend toward classical music and technical support personnel prefer popular and country-western music.

Some of the other significant activity findings are:

- Some activity preferences change as a result of confinement. The most striking example is movies. Antarctic studies indicate that unconfined Antarctic personnel do not frequently watch movies and similar entertainment (such as TV). However, when confined in Antarctica, movies had the highest frequency of use.

- Participation in physical exercise by most of the groups studied was insufficient in frequency to meet the expected requirements for exercise which reduced gravity will impose.

- None of the most preferred sports can be performed in the spacecraft as they are performed on Earth.

- Games are not highly desired by potential crew members.

- Currently available preference questionnaires are not adequate for gathering reliable information on the preferences of individuals, particularly with regard to time spent on each activity.

Off-Duty Equipment Considerations

Equipment requirements for selected activities were developed. Because of the unusual environmental constraints, innovative ideas for equipment which would meet these requirements were sought from selected companies.

The equipment required to support the selected activities include:

Activity	Selected Equipment
Watching TV shows	Television set, tape cartridges, cartridge players.
Watching movies (space base only)	Movie projector, movie film.
Reading books	Hard copies, microfilm, microfilm reader.
Reading magazines	Tape cartridge, cartridge player, microfilm production equipment, microfilm reader, character generator, TV set, automatic typewriter.

Activity	Selected Equipment
Listening to music	Tape cartridge, cartridge player, group and individual speakers, headsets.
Games	Darts, target equipment, chess, checkers, scrabble, cards, individually chosen hobby equipment.
Sports	Spring return nets, sports inventor's kit, balls, rackets, etc.
Exercise	Resistive exercise equipment, performance improvement equipment.
General leisure	Chairs, tables, personal chambers, screens for noise, writing materials, communication to Earth, viewports in space station, photographic equipment.

Some general findings for equipment are:

- Preference for up-to-date information for reading and other activities requires heavy reliance on a communication link with Earth.
- Some means of providing for privacy were developed.
- Because forced exposure to music which is disliked can be extremely annoying, the equipment suggested for listening to music was selected to reduce the possibility of conflict.
- Prevention of physiological deterioration in reduced gravity will require regular performance of an exercise program. Peripheral heart action training programs appear best able to meet biomedical goals. Resistive equipment is presently feasible which would permit this type of program to be developed.

- Means to increase crew motivation to exercise were suggested including display of parameter requirements, establishing a game/sport orientation and recommending "handicaps" to equalize competition.

- A kit of items (including balls, rackets, marking materials such as tapes, etc.) which would permit creative development of new sports on the spacecraft was suggested.

Recreation Facility Layout Considerations

After activities and equipment characteristics were identified, various configurations for the overall recreational facilities were developed. General principles for optimizing habitability and for recreation space layout were used to select among the potential configurations. Overall facility layouts were developed, illustrating not only the facilities themselves but also the activities that might be performed.

Layouts for the space station are shown in Figure 1. The two halves of the space base are shown in Figure 2. Additional findings made at this stage that are not apparent from the figures are:

- It is difficult to accommodate both active and sedentary recreation simultaneously in the space station.

- Separate facilities are recommended for the space base to accommodate sports/exercise and general leisure. However, even with the two compartments, the space base facilities are inadequate to accommodate the entire crew simultaneously except at certain passive group functions such as movies or television.

- Sports are virtually impossible within the $6\frac{1}{2}$ foot floor to ceiling distance of the space base; particularly with its 0.3 gravitational field.

- It was easier to design for the zero gravity space station since the "floor" selection could be based upon the requirements of the activity.

- Hard and soft (inflatable) materials for the construction of the facilities were recommended.

STUDY LIMITATIONS, IMPLICATIONS FOR OTHER RESEARCH AND ADDITIONAL EFFORTS

In the course of developing the preliminary designs, a number of information and data limitations were uncovered. Chief among these were:

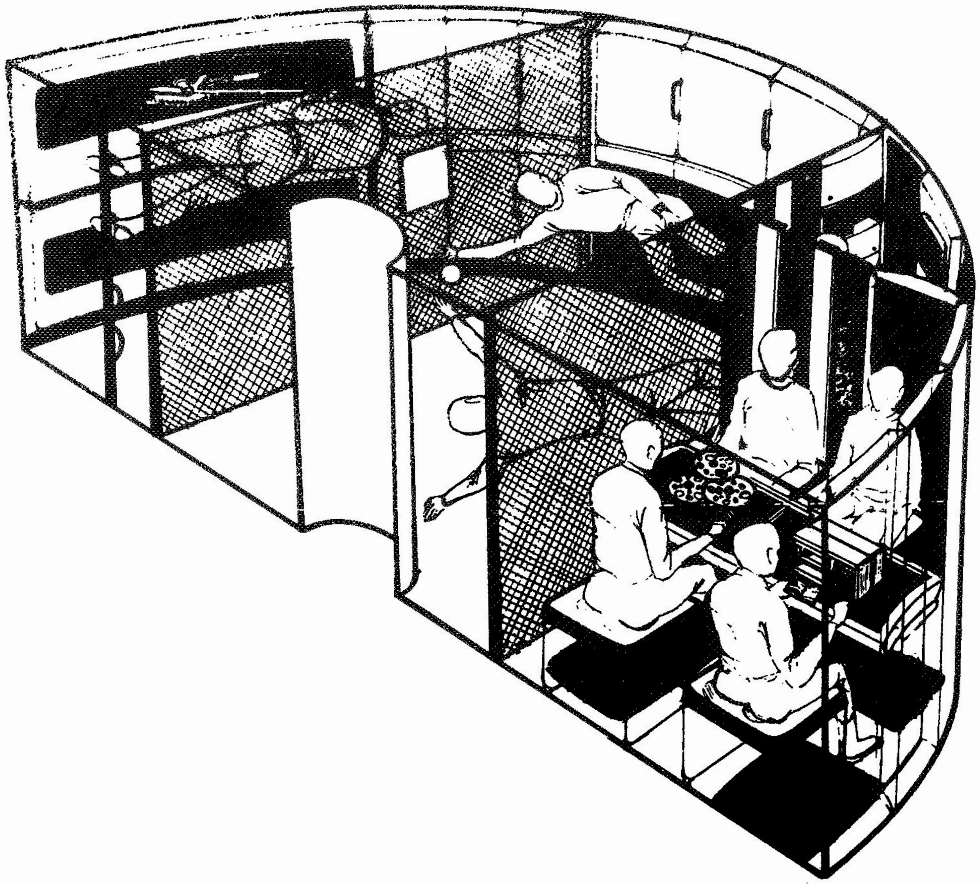
- Inadequate information on the biomedical criticality of exercise for space missions.

- Inadequate information on the feasibility or desirability of providing competitive exercise programs.

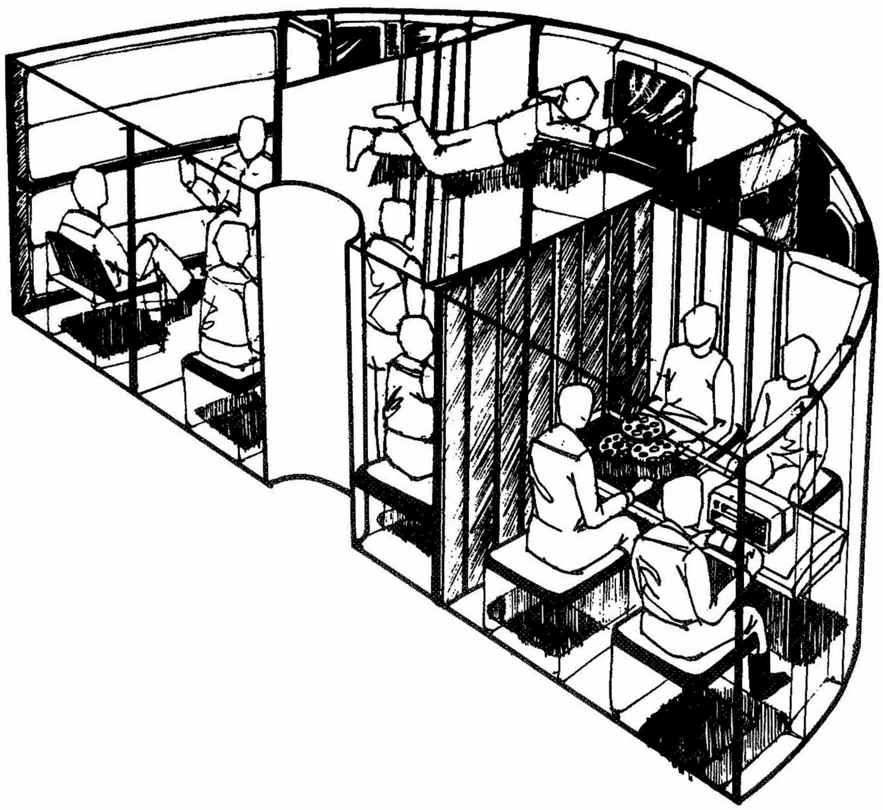
- Inability to predict what an individual crewman's off-duty requirements will be (except on a probability basis).

- Lack of information on the acceptability of audio-visual devices for presenting leisure reading materials.

Other information and data limitations together with research and development requirements are presented in Table 2. It should be noted that the information and data limitations generate the research and development requirements.

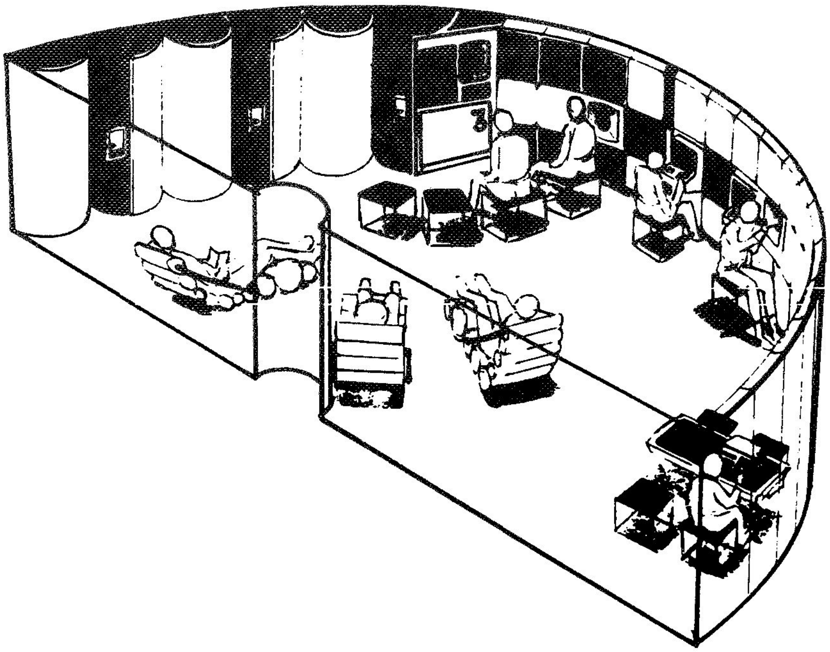


EXERCISE. SPORTS AND LEISURE DEPLOYMENT

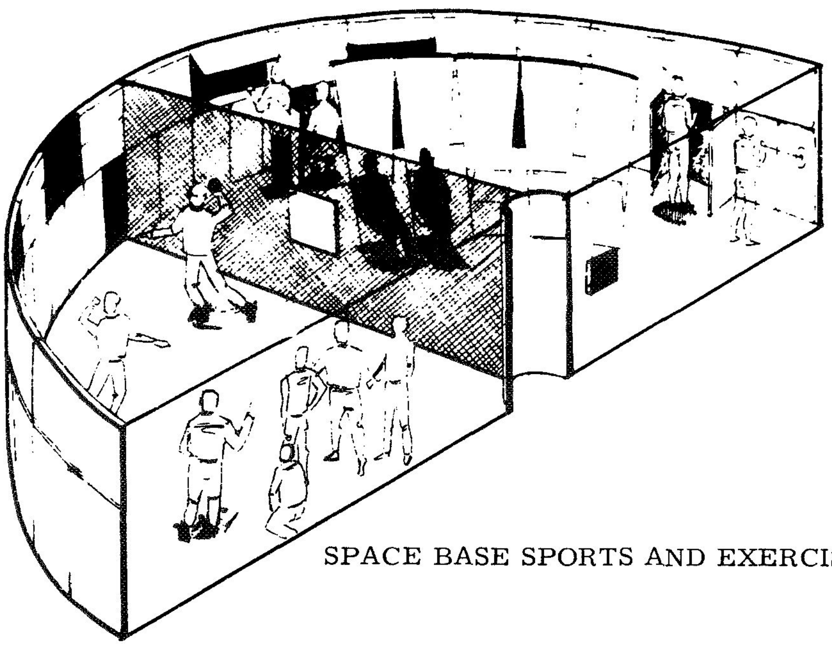


LEISURE DEPLOYMENT

FIGURE 1. SPACE STATION FACILITY CONFIGURED FOR MULTIPLE AND LEISURE



SPACE BASE LEISURE FACILITY



SPACE BASE SPORTS AND EXERCISE FACILITY

FIGURE 2. SPACE BASE LEISURE FACILITY AND SPORTS AND EXERCISE FACILITY

TABLE 2

ADDITIONAL INFORMATION AND REQUIREMENTS NECESSARY FOR THE DEVELOPMENT OF OFF-DUTY FACILITY FOR SPACE STATIONS AND SPACE BASES

INFORMATION AND DATA REQUIREMENTS	RESEARCH REQUIREMENTS	DEVELOPMENT REQUIREMENTS
SPACECRAFT CONSIDERATIONS		
Adequate standards to determine the volume required for the performance of off-duty activities for crews of varying size.	A literature review and on site measurement and analysis of volume allocated for off-duty time in comparable environments.	Establish relative volume needed for proposed equipment and facilities based upon the maximum number of pieces of equipment required simultaneously in both stowed and deployed states.
Feasibility of using other areas of the spacecraft for off-duty time.		Integration of off-duty facility requirements into total preliminary design for the space station and space base.
EXERCISE CONSIDERATIONS		
Adequate standards for the biomedical criticality of exercise related to current physiological status and the impact of prolonged confinement and reduced gravity.	A research program to determine the long term effects of reduced gravity in a confined environment and the impact of various types and protocols of exercise.	
	Test the relative merits of potential exercise equipment, e.g., bicycle ergometer vs resistive exercise devices. These time oriented studies should include biomedical performance measurements and crew acceptability.	Design and test desirable exercise equipment suitable for the space environment.

INFORMATION AND DATA REQUIREMENTS	RESEARCH REQUIREMENTS	DEVELOPMENT REQUIREMENTS
EXERCISE CONSIDERATIONS (CONT.)		
Data on techniques to motivate individuals to exercise.	A survey of techniques used to motivate individuals, e.g., executives, athletes, those being rehabilitated and analysis of their application to the exercise requirements in space.	
	Develop and test techniques to enhance use of potential exercise devices.	Design and test displays and controls to enhance the use of exercise devices.
Feasibility and desirability of developing competitive exercises.	Determine and test the feasibility of establishing exercise "handicaps" that would permit competition among confined personnel.	Develop techniques to permit on board updating of exercise "handicaps".
ACTIVITY PREDICTION CONSIDERATIONS		
Accurate prediction techniques of individual activity and equipment utilization during confinement.	Develop and test preference schedules predictive of the activities an individual would perform during confinement.	
Specific content preferences for reading, TV/movies, educational materials, music, news, and sports programs.		Develop tools for the designers of off-duty activity equipment and software to permit the identification of specific content areas.
EQUIPMENT CONSIDERATIONS		
Acceptability of audio-visual systems as a means of presenting leisure reading.	Test the acceptability of various audio-visual means of presenting different types of reading materials to confined personnel.	Develop functional hardware specifications based upon audio-visual acceptability studies and state of the art.

INFORMATION AND DATA REQUIREMENTS	RESEARCH REQUIREMENTS	DEVELOPMENT REQUIREMENTS
EQUIPMENT CONSIDERATIONS (CONT.)		
Detail design and tests of selected off-duty equipment items.		Design of hard/soft shell equipment concepts including mock-ups.
		Fabrication and test of hard/soft shell equipment concepts.
FACILITY CONSIDERATIONS		
Detail design of integrated facility.		Design of hard/soft shell facility concept including mock-ups.
		Fabrication and test of hard/soft shell facility concepts.
TEST CONSIDERATIONS		
Identification of appropriate test sites and personnel for testing off-duty activity, equipment, and facility concepts.	A literature review and analysis of available sites and personnel required to permit generalization to crew members of advanced space missions.	
Effectiveness of enhancing improverished confined environments with adequate off-duty facilities.	Test the effects of off-duty facilities on confined crew performance, physiological, and psychological well being.	Design and fabricate prototype or representative off-duty facilities for studies of the effectiveness of off-duty facilities.
MANAGEMENT CONSIDERATIONS.		
Program plan to establish the details for systematic research and development in the off-duty time area.		Develop detailed program plan for space station and space base off-duty facility requirements.

As can be seen from Table 2, there are many requirements that must be met before adequate off-duty facilities can be designed. However, present efforts are not directed by a comprehensive plan. The interrelation of the various requirements and the relatively short time before hardware integration is required, dictates the need to develop a systematic program plan. It is recommended that this plan plus the critical, long lead time research and development requirements established by the plan be undertaken as the next step.

CHAPTER II

INTRODUCTION

A number of studies (Eddowes, 1961; Eberhard, 1967; Landis, et al, 1969; Eberhard, 1970) have addressed the general problem of off-duty time activities in space missions of varying lengths. However, it is generally agreed that there has been inadequate attention paid to the off-duty time problem. Indeed, off-duty time in remote isolated facilities is a frequent cause of morale problems. These are manifested in a reduced number of re-enlistments (Department of the Air Force, 1952) or abnormal symptomology (Gunderson, 1966).

Several recent studies have attempted to identify the off-duty time characteristics of personnel in remote sites (Doll and Gunderson, 1969; Zill, et al, 1969; Eberhard, 1970). A number of preference schedules have have been developed (Eddowes, 1961; Doll and Gunderson, 1969; Landis, et al, 1969) for identifying off-duty time activity and equipment. Analyses of these schedules indicated that some broad guidelines for facility requirements can be identified. However, identification of specific individual requirements is beyond the scope of current preference schedules (Eberhard, 1970). None of the above studies has adequately derived the equipment requirements for a desirable leisure facility.

This study reviews the constraints of the proposed missions, analyzes crew preferences for off-duty activities, considers the effect of confinement on these preferences, and develops estimates of off-duty equipment and facility requirements for proposed stations and bases.

APPROACH

The approach closely followed the study plan outline which is diagrammed in Figure 3.

The starting point was data on preferences of astronauts and persons in other occupational groups similar to those that might be included on advanced space missions. These data were obtained from the Off-Duty Activities Survey (Landis, et al, 1969) and the analysis and extension of that study performed by Eberhard (1970). Additional information on the preferences and characteristics of confined groups was obtained from the Doll and Gunderson (1969) survey of civilian scientists, technical administrators, and Seabees in Antarctica. Preference data collected by Eddowes (1961) was used to determine whether there have been changes in leisure preferences with time.

The data from the above studies were reviewed against the objectives of the current study; namely, the identification of leisure equipment requirements for space stations on the one hand and space bases on the other. The preference data suggested that there were two general classes of people with somewhat different off-duty time activity needs; professional personnel and technical support personnel.

The importance of this finding for facility design requirements was clarified by analyzing the anticipated crew composition for space stations and space bases for the proportions of professional and technical support personnel expected for each type of mission. The space station will be manned by professional personnel with relatively similar off-duty time requirements. The space base, on the other hand, will have both professional and technical support personnel. The recreational facility design requirements for the space base are therefore more complex than for the space station.

An extensive review of the state of the art in recreation and exercise equipment was performed. Samples of some potentially usable equipment together with catalogs and relatable materials were obtained from an array of manufacturers. Based upon a careful review of the products and capabilities of various organizations, those most likely to provide creative and useful products were identified.

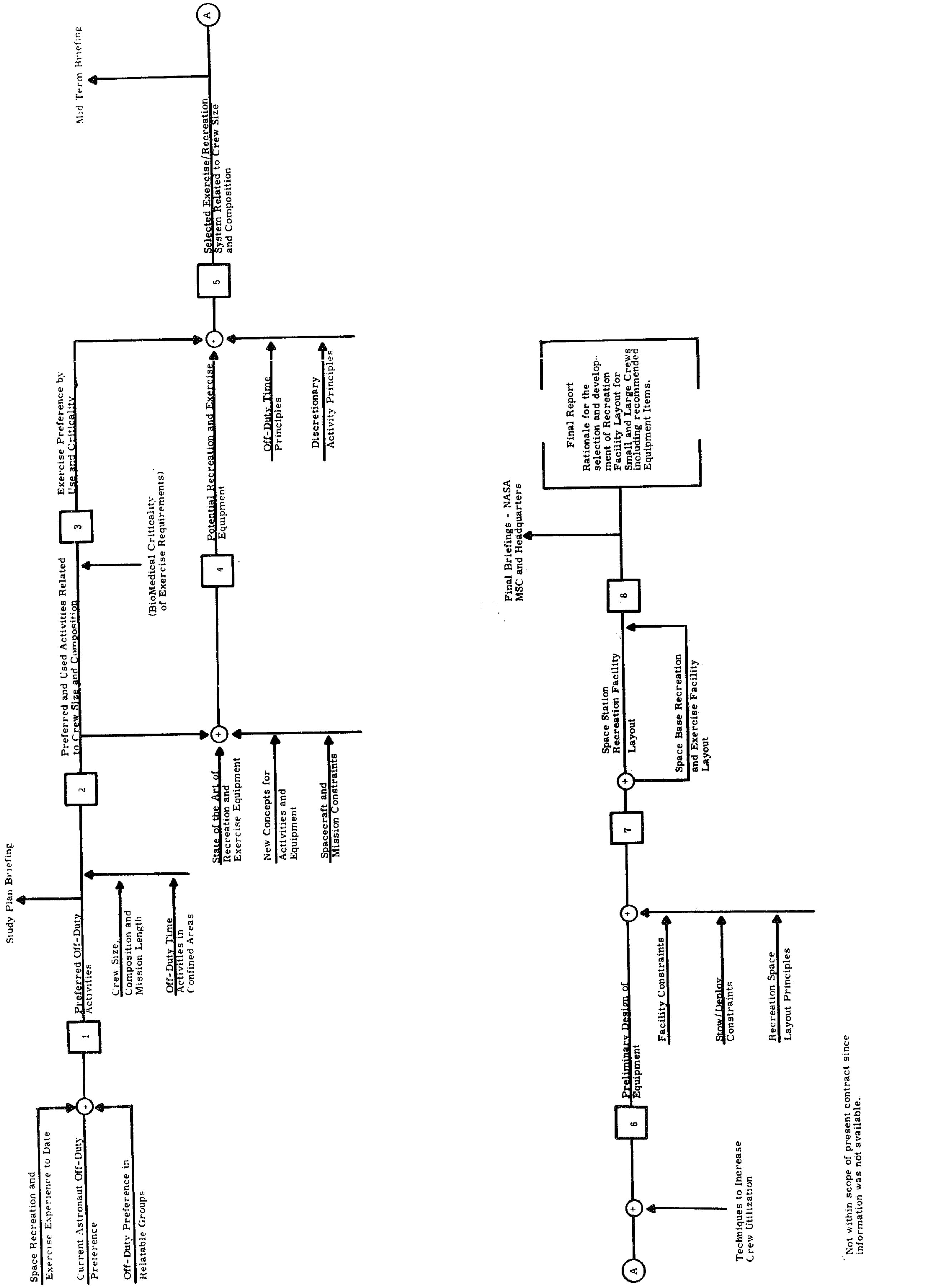


FIGURE 3. FUNCTIONS REQUIRED TO ANALYZE, DESIGN, AND DOCUMENT EXERCISE/RECREATION EQUIPMENT AND FACILITIES.

Information and ideas were sought in the areas of exercise, sports, audio-visual equipment, games, and leisure time furniture. The review identified a number of individuals, frequently company presidents, who were extremely cooperative and provided many useful inputs to the study. Through combined telephone and letter follow-ups, a number of creative activities for both exercise and other requirements were identified. In addition, an attempt was made to involve the public in identifying off-duty sports and exercise activities by placing a letter in Analog Science Fiction (unfortunately, that letter will not be published in time for any results to be included in this report).

Potential recreation and exercise concepts were evaluated by means of off-duty time and discretionary activity principles (Eberhard, 1970). Selected recreation equipment concepts in the areas of reading, audio-visual equipment, exercise, sports, games, and leisure functions were presented to personnel at the NASA Manned Spacecraft Center, and at NASA Headquarters. Comments were solicited and received on such subjects as the spacecraft, the constraints, and the impact of reduced gravity on recreation system design and on the selected activities and equipment.

After identifying an acceptable set of activities and equipment for each of the two types of space missions, design of the equipment in accordance with constraints was undertaken (Chapter IV). Also, consideration was given to means to increase crew morale and increase motivation to use the exercise equipment. Finally, designs for the facilities themselves for both the small space station and the large space base were developed (Chapter V).

CONSTRAINTS

The request for proposal did not provide separate facility constraints for space stations and space bases. For example, the dimensions of the recreational facility were given as half of a 22 foot cylinder, 78 inches in height. However, for the space station, the manning was indicated as 6 to 12 crew members whereas for the space base, the manning was indicated as 50 to 100 crew members.

In the initial phase of the study, it was decided that 50 to 100 crew members could not be adequately accommodated by the dimensions of the recreational facility identified in the procurement. Therefore, it was requested that the area allocated for off-duty activities in the space base be reconsidered. After review of the problem, MSC allocated two halves of a 33 foot diameter cylinder, each 78 inches high, for off-duty activities in the space base. The two halves will be on separate levels, each with an airlock.

An analysis of the area allocated for off-duty activities in the space station and base was performed. Some of the results of the analysis related to crew size are presented in Figure 4. The "assumed" floor for the zero gravity station leisure facility has an area of 184 square feet. The floor area for both halves of the 0.3 gravity space base recreation facility totals 842 square feet.

Comparing the square footage available per crew member for leisure activities, we find that there is approximately half the area available per man in the space base. Whereas there will be 30.6 to 15.3 square feet per man for the 6 to 12 men, respectively, in the space station there will be only 16.8 to 8.4 square feet per man for the 50 to 100 men, respectively, in the space base.

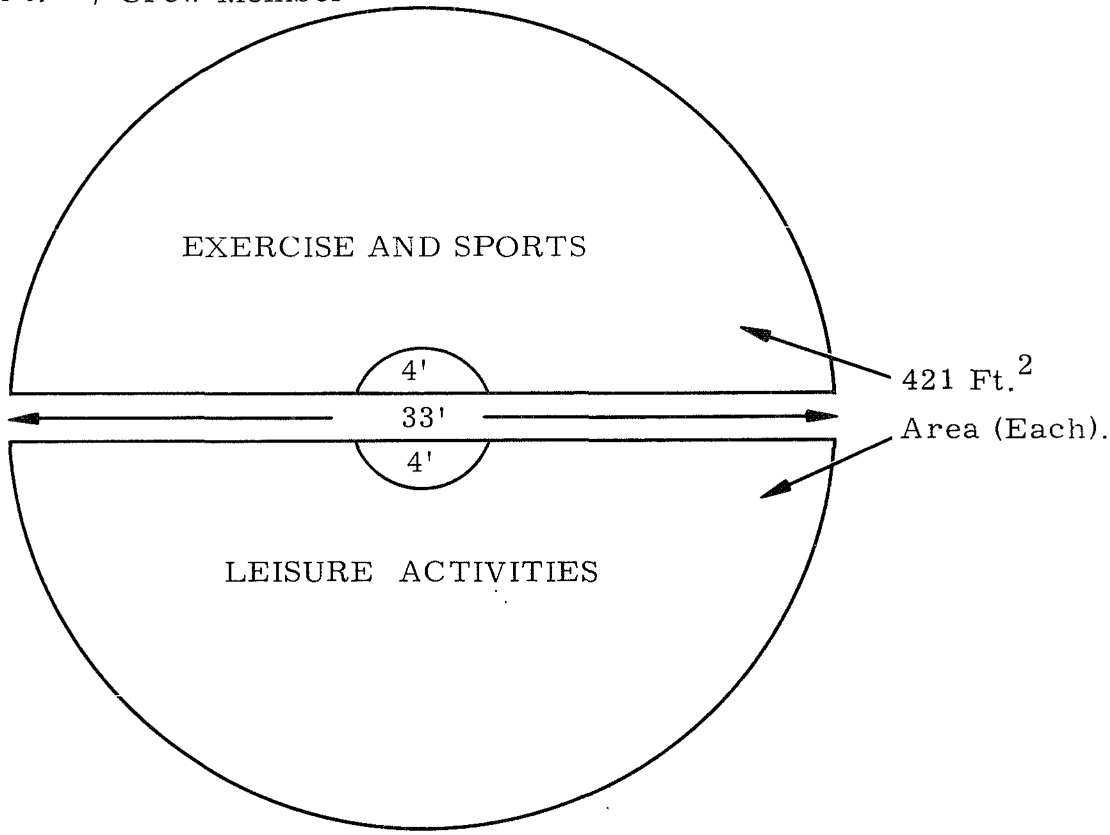
An attempt was made to determine how much volume should be allocated for off-duty activities. The only reference (MSC, 1966) indicated 15 to 20 square feet per man would be desirable for the exercise facility alone. This estimate was based on the assumption that only one-third of the crew would be using the facility at any given time because of three work shifts. However, present mission planning indicates one work shift. Using the MSC (1966) estimate for exercise area,

SPACE BASE

TWO (SEPARATE FACILITIES)

50 - 100 Men

16.8 - 8.4 $Ft.^2$ / Crew Member



SPACE STATION

6 - 12 Men

30.6 - 15.3 $Ft.^2$ / Crew Member

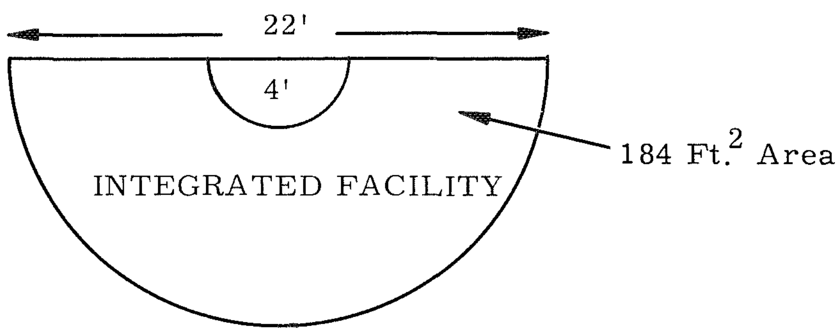


FIGURE 4. AREA ALLOCATED FOR OFF-DUTY ACTIVITIES IN PROPOSED SPACE STATION AND SPACE BASE.

modified for one work shift, the floor area for exercise in the space station should be increased 50 to 400%. Similarly, the floor area in the space base should be increased 270 to 700%.

The specific rationale for selecting the exercise volume requirements was not presented in the report (MSC, 1966) and no other source for estimating off-duty volume requirements was found. Given the above figures and the difficulties encountered in the facility design phase (Chapter V), further research is required to determine the volume necessary for off-duty activities.

Before proceeding further, it is necessary to identify and differentiate the facility constraints for the space station and the space base. These constraints serve as guidelines for selecting the activities and equipment and for the overall design of the facilities. The constraints are presented below:

Space Station

Crew. The space stations that are currently anticipated will accommodate crews varying in size from 6 to 12 men. In general, these will be personnel who are technically trained in piloting, navigation systems, astronomy, earth resource sensors, and biomedical experimentation.

Facility. The anticipated size of the off-duty facility is half of a 22 foot cylinder (including half of a four foot cylinder airlock) and is 78 inches in height.

Gravity. It is assumed that the space station will have zero gravity. The floor of the recreational facility has been assumed to be one of the two non-curved semicircular sufaces. Therefore, the floor area will be 184 square feet.

Time Frame. The time frame for launching of the space station is anticipated as approximately 1975.

Mission Length. Missions are expected to last from 3 to 6 months.

Normal Duty Day. Work--8 hours; eat--3 hours; sleep--8 hours; off-duty time--5 hours; all crewmen are off-duty at the same time.

Resupply Interval. It is anticipated that there will be no resupply interval for the space stations and any additional off-duty activity requirements (e.g., reading materials) must be provided by communication.

State of the Art. Because of the long lead times required to integrate the equipment into the facility, it is anticipated that all items of equipment for the space station must be state of the art by 1973, allowing two years for systems integration.

Stowability and Deployability. It is desirable that all equipment and facility requirements should be stowable or deployable by one man. However, if a particularly intriguing and useful equipment or facility requirement is identified which requires more than one man, the reason for its existence in a multi-man stowage or deployment configuration will be specified.

Space Base

Crew Size. Crew size will vary from 50 to 100 men. Crew composition will be more diverse than in the space station with both professional and technical level personnel. The professionals will comprise from 50 to 60% of the group and include astronauts, engineers, scientists, mathematicians, and doctors. The technicians will comprise from 50 to 40% of the base and include housekeepers, clerks, suppliers, and general technicians. The crew composition of the space base is expected to be similar to the crew composition of a nuclear submarine.

Facility Size. In the space base, there will be two facilities. The size of each will equal half of a 33 foot diameter cylinder (including half of a four foot cylinder airlock) which is 78 inches high. The facilities will be on separate levels and therefore, the areas cannot be combined to form one large facility.

Gravity. The gravitational field anticipated for the space base is approximately 0.3 g, oriented along the major axis of the cylinder. The floor of the facility on each level will therefore be semicircular in shape and 421 square feet in area.

Time Frame. The time frame for the space base is expected to be the late 1970's.

Mission Length. Mission length is anticipated to be 3 to 6 months.

Normal Duty Day. Work--8 hours; eat--3 hours; sleep--8 hours; off-duty time--5 hours; all crewmen are off-duty at the same time.

Resupply Interval. It is expected that the space base will be supported by a space shuttle scheduled approximately every 30 days.

State of the Art. The anticipated state of the art for estimating off-duty activity equipment requirements for the space base will be 1976 to facilitate systems integration.

Stowability and Deployability. One man stowability and deployability will still be attempted; however, with the large complement of crew members, waiving of this requirement should be considered.

The above constraints were used to:

1) Filter preferred activities to identify those that can be performed.

2) Guide the selection of equipments necessary to support preferred activities.

3) Guide the preliminary design of the recreation facilities.

4) Identify additional research and development requirements.

CHAPTER III

SELECTION OF OFF-DUTY TIME ACTIVITIES

The first step in the design of an off-duty recreational facility must be identification of the activities which should be included in the facility. The logical approach to identifying these activities is to determine the off-duty activity preferences of persons similar to those who will be included as crew members. From these preferences, a subset of activities can then be identified that will be compatible with spacecraft and mission constraints.

Unfortunately, preferred activities and the distribution of time spent in the preferred activities may change as a function of individuals being in a confined or isolated environment. Understanding of confinement effects on activity preferences is incomplete at the present time. Nevertheless, it appears that sufficient data is available to identify activities which would be utilized by confined and isolated men in advanced space missions. The following approach was used to select off-duty activities for inclusion in the advanced space mission recreational facilities:

1) Analysis of data from questionnaire studies of preferred activities, activity contents, and equipment (Eddowes, 1961; Landis, et al, 1969; Eberhard, 1970).

2) Analysis of the effects of confinement and crew characteristics on off-duty activities (Doll and Gunderson, 1969; Eberhard, 1970).

3) Consideration of the impact of spacecraft and mission constraints on feasibility of activities.

PREFERENCE QUESTIONNAIRE STUDIES

Landis, et al (1969) designed a questionnaire and obtained responses to it from 44 pilots from the Aerospace Research Pilot School (ARPS), 37 tactical fighter pilots, and 53 aerospace engineers. Subsequently, the same questionnaire was administered to 30 astronauts under the direction of Mr. Joe E. Reed from MSC Crew Systems Division. Some of the crew members for advanced missions are expected to come from these four groups of personnel or from groups like them.

Three of the four parts of the questionnaire designed by Landis, et al (1969) dealt with preferred activities and equipment. These were:

1) A schedule of 21 present off-duty activities. Those surveyed rated their present participation in the 21 activities on a five point scale (Very small amount, Small, Moderate, Large, Very large amount).

2) A schedule of 19 leisure equipment items. Those surveyed rated their anticipated usage of these items in the spacecraft on a five point scale (Very little use, Little, Moderate, Much, Very much).

3) Five schedules of content preferences. A five point rating scale (Dislike very much, Dislike, Neutral, Like, Like very much) was used by those surveyed to indicate their preferences. The five schedules covered content preferences in

   - Reading
   - TV/radio/movies
   - Music
   - Sports and exercising
   - Games and puzzles

Similarities in Leisure Preferences

The four groups were quite similar in present activities, content preferences, and desired leisure equipment in the spacecraft. Preferences for present off-duty activities were pooled, since there were no statistically significant differences for the groups and the correlations among the groups were high (Table 3). The mean and rank order preferences in present activities and their spacecraft feasibilities for the combined groups are presented in Table 4. Details for each group may be found in Appendix A.

The aerospace engineers were least similar to the other groups (Table 3). This was due to their low ranking of "Job Related Activities". If that item is disregarded, the correlations between the aerospace engineers and the astronauts, tactical fighter pilots, and the ARPS personnel are 0.79, 0.82, and 0.86, respectively (compare to correlations in Table 3 where "Job Related Activities" is included).

The four occupational groups were similar in their predictions of equipment usage. These correlations (Table 3) are generally larger than those found for present off-duty activities. Thus, there is a greater similarity between occupational groups in terms of their anticipated activities (or equipment usage) than in terms of their present activities. An analysis of variance of the equipment usage data demonstrates no group or group x item effects. There were significant differences between expected use of particular equipment.* The rank and mean preferences for desired leisure equipment in the spacecraft are presented in Table 5.

*F=66.58 with 20 and 1436 degrees of freedom.

TABLE 3

RANK ORDER CORRELATED PREFERENCES AMONG ASTRONAUTS, TACTICAL FIGHTER PILOTS, ARPS, AND AEROSPACE ENGINEERS

	Present Off-Duty Activities		
	Tactical Fighters	ARPS	Aerospace Engineers
Astronauts	.86	.95	.64
Tactical Fighters		.86	.72
ARPS			.68

	Equipment Usage in Spacecraft		
	Tactical Fighters	ARPS	Aerospace Engineers
Astronauts	.93	.92	.96
Tactical Fighters		.89	.91
ARPS			.92

TABLE 4

MEAN AND RANK ORDER PREFERENCES OF PRESENT OFF-DUTY ACTIVITIES

Spacecraft Feasibility	Present Off-Duty Activity	(n = 164) Rank	Mean**
Yes	Reading	1	3.38
Yes	Studying or Coursework	2	2.93
P.E.*	Family Activities	3	2.92
Yes	Job Related Activities	4.5	2.90
Yes	Physical Exercises	4.5	2.90
Yes	Listening to Records, etc.	6	2.77
Yes	Sports	7	2.71
Yes	Watching TV, movies, etc.	8	2.48
Yes	Religious Activities	9	1.97
Yes	Being Alone	10.5	1.87
Yes	Model Building, etc.	10.5	1.87
Yes	Resting, Relaxing, or Doing "nothing in particular"	12	1.79
Yes	Snacks	13	1.72
Yes	Technical Writing	14	1.66
Yes	Card Games	15	1.63
Yes	Personal Writing	16.5	1.61
Yes	Painting, Sculpting, Photography	16.5	1.61
Yes	Board Games	18	1.50
Yes	Musical Instruments or Singing	19	1.49
Yes	Gambling Games	20	1.36
Yes	Stamp or Coin Collecting	21	1.13

**Note: 1.00 to 1.81 indicates up to a few times a month.
1.82 to 2.54 indicates up to weekly.
2.55 to 3.26 indicates up to a few times a week.
3.27 to 5.00 indicates up to daily.

*P.E. = Phenomenally Equivalent, i.e., although the activity cannot be performed with its normal means, we believe we can provide equivalent means.

TABLE 5

MEAN AND RANK ORDER PREFERENCES OF DESIRED OFF-DUTY TIME EQUIPMENT FOR SPACECRAFT UTILIZATION

Spacecraft Feasibility	Equipment Usage in Spacecraft	(n = 164) Rank	Mean*
Yes	Viewports in Spacecraft	1	3.59
Yes	Physical Exercise Equipment	2	3.42
Yes	Books	3	3.40
Yes	Records or Tape Player	4	3.38
Yes	AM or FM Radio	5	3.25
Yes	Sports Equipment	6	3.23
Yes	Newspapers	7	3.07
Yes	Magazines	8	2.92
Yes	Television Set	9	2.87
Yes	Radio Equipment for Personal Communication	10	2.77
Yes	Photo Equipment	11	2.60
Yes	Playing Cards	12	2.31
Yes	Writing Supplies	13	2.29
Yes	Board Games	14	2.13
Yes	Model Building Kits	15	1.96
Yes	Musical Instruments	16	1.85
Yes	Painting/Drawing Supplies	17	1.72
Yes	Dice	18	1.52
Yes	Stamp or Coin Collecting	19	1.17

*Note: 1.00 to 1.96 indicates up to a few times a month.
1.97 to 2.74 indicates up to weekly.
2.75 to 3.52 indicates up to a few times a week.
3.53 to 5.00 indicates up to daily.

A study was performed (Eberhard, 1970) to determine the feasibility of converting the five point Landis, et al (1969) scale into a frequency of use scale. The frequency scale was: "Few times a year, Few times a month, Weekly, Few times a week, and Daily".

Twenty aerospace engineers answered the Present Off-Duty Activities and Equipment Usage on Spacecraft questionnaires using both the original scale and the frequency scale. The experiment was counterbalanced; half the group received the frequency scale first and the other half received the original scale first.

The scale study indicated that one cannot map an individual's original responses into the frequency of use scale. The reason is that the correlations were small, and account for less than 50% of the variance. However, the findings show that an average score on the original scale can be converted to an average score on the time anchored scale. The correlations between the mean values of the two scales are:

1) .97 for present off-duty activities.

2) .91 for expected equipment usage.

Therefore, there is considerable predictive accuracy on the basis of mean scores. The time oriented scale values are presented as notes to Tables 4 and 5. This scale facilitates the estimation of the frequency of use of activities and equipment. Such data are useful to estimate the number of pieces of equipment required.

Content preferences for reading, TV/radio/movie, music, sports, and games were subjected to an analysis of variance to determine whether there were preferences peculiar to one or more of the four groups. Table 6 summarizes the significant differences found in these analyses. There were significant differences due to content preferences within each activity area. However, only in the case of games and puzzles was there a significant group difference (F = 4.86 with 12 and 1508 degrees of freedom). A major portion of the group differences found in games and puzzles can be attributed to the generally higher rating given to ping pong, chess, darts, pool, poker, and checkers by the astronauts. Relative to the other games presented in this survey, the six mentioned above are more competitive in nature and generally involve two to four players. It is also interesting to note that in the area of sports and exercising, the astronauts play handball more often than the other three occupational groups. Of all the sports and exercises sampled, handball is most similar in terms of competitiveness and number of players to the games mentioned above.

TABLE 6

SIGNIFICANT F VALUES FOR SPECIFIC OFF-DUTY ACTIVITY AREAS FOR ASTRONAUTS, AEROSPACE ENGINEERS, TACTICAL FIGHTER PILOTS, AND ARPS

	Significance Due To		
Off-Duty Activity Areas	Groups	Content	G x C*
Present off-duty activities		.01	
Expected equipment usage		.01	
Reading matter		.01	
TV/radio/movie content		.01	
Games and puzzles	.01	.01	
Sports and exercising		.01	
Music		.01	

*There were no significant group by content interactions.

Similarities Between Present Activities and Preferred Leisure Equipment for Spacecraft

To determine whether present off-duty activities were predictive of anticipated equipment usage within each of the four groups of personnel tested, correlations were computed between the overlapping items. The overlapping items appeared in both scales. The results of this analysis for each occupational group are presented in Table 7. The Spearman correlations are of considerable size (astronauts = .93; ARPS = .93; tactical fighter pilots = .83; aerospace engineers = .73; and Total = .95). This indicates that present activities were predictive of anticipated equipment usage within personnel groups. The similarity of ranking between groups should also be noted.

The corresponding correlations for the individual overlapping items are presented in Table 8. This analysis was done to evaluate the possiblity of predicting anticipated usage of particular equipment items from present activities. These relatively large correlations indicate that present activities are highly related to anticipated equipment usage.

Comparison of Results With Those Obtained by Eddowes (1961)

In 1961, Eddowes conducted a survey of leisure preferences among eighty aerospace engineers. A questionnaire was used and preferences were sought in areas similar to those in the Landis, et al (1969) questionnaire; namely, present leisure activities, leisure equipment desirable for a space journey, preferred athletic activities, and participated-in athletic activities.

The results obtained by Eddowes (1961) were compared to those obtained in the current study to estimate the degree of consistency.

TABLE 7

RANK ORDER AND CORRELATIONS OF EQUIPMENT USAGE AND PRESENT OFF-DUTY ACTIVITIES

Equipment Usage	Present Off-Duty Activities	Total Usage	Total Present
Physical Exercise Equipment	Physical Exercises	1	1
Sports Equipment	Playing Sports	2	2
TV Set	Watching TV, movies, etc.	3	3
Playing Cards	Playing Card Games	4	5
Writing Supplies	Personal Writing	5	6
Model Building Kits	Model Building, etc.	6	4
Board Games	Playing Board Games	7	7
Musical Instruments	Playing Musical Instruments	8	8
Stamp or Coin Collecting	Stamp, Coin Collecting	9	9

ρ_{xy} = Total = .95

Astronauts	= .93
ARPS	= .93
Tactical Fighter	= .83
Aerospace Engineers	= .73

TABLE 8

CORRELATIONS BETWEEN OVERLAPPING PRESENT OFF-DUTY TIME ACTIVITY PREFERENCE AND EQUIPMENT USAGE

Present Off-Duty Activities	Equipment Usage in Spacecraft	Astronauts (n = 30)	ARPS (n = 44)	Tactical Fighter (n = 37)	Aerospace Engineers (n = 53)
Reading	Books	.32	.28	.54	.39
Reading	Magazines	.12	.28	.49**	.37**
Reading	Newspapers	.07	.40**	.46**	.35**
Listening to Records	Record or Tape Player	.38*	.59**	.66**	.46**
Listening to Records	AM or FM Radio	.35	.43**	.62**	.50**
Watching TV or Movies	TV Set	.62**	.73**	.42**	.56**
Stamp, Coin Collecting	Stamp or Coin Collecting	1.00[a]	1.00[a]	.72**	.83**
Playing Card Games	Playing Cards	.59**	.60**	.53**	.62**
Playing Board Games	Board Games	.31	.65**	.70**	.36**
Personal Writing	Writing Supplies	.32	.61**	.61**	.44**
Technical Writing	Writing Supplies	.70**	.06	.10	.36**
Model Building	Model Building	.64**	.49**	.65**	.36**
Playing Musical Instruments or Singing	Musical Instruments	.74**	.55**	.66**	.82**
Physical Exercise	Physical Exercise Equipment	.32	.33*	.38*	.37*
Playing Sports	Sports Equipment	.54**	.28	.42**	.43**

* Significant beyond .05 level

** Significant beyond .01 level

a These correlations are most likely spurious due to the fact that they are attributable to one or two cases.

Specific comparisons were made of:

1) Current leisure activities for 1961 vs 1969 for relatable items (Table 9).

2) Desired leisure equipment in the spacecraft for 1961 vs 1969 (Table 10).

3) Current leisure preferences and desired leisure equipment in the spacecraft for both groups for each time period (Table 11).

The correlations between the two groups of aerospace engineers on current leisure activity preferences was 0.50 (Table 9).

TABLE 9

RANK ORDER OF CURRENT LEISURE TIME ACTIVITIES OF AEROSPACE ENGINEERS: 1961 and 1969

Activity	Rank 1961 (n = 80)	Rank 1969 (n = 54)
Reading	1	1
Television	2	4
Musical Activities	3	3
Playing Bridge	4	10
Educational Activities	5	5
Miscellaneous Work	6	8
Family Activities	7	2
Sports	8	6
Art Activities	9	9
Making Models	10	7

$\rho_{xy} = 0.50$

The most striking finding was the marked difference in equipment desired in the spacecraft (Table 10). The rank order correlations for the two groups is essentially zero (0.06). The 1969 aerospace engineers may have better insight into the requirements which space missions will impose (e.g., exercise) and the possibilities they will present (e.g., taking pictures of Earth). The relatively high rankings given to athletic equipment and photographic equipment by this group compared to the 1961 group suggests such conclusions. The 1969 aerospace engineers may also have better insight into themselves and the activities they are therefore likely to undertake in confinement. Note their low rankings for cards, musical instruments, and art supplies compared to the rankings given these equipments by the 1961 group. As will be shown below (in the discussion of the Doll and Gunderson (1969) study) such activities as cards and playing musical instruments are infrequently sought activities by men in confinement.

TABLE 10

RANK ORDER OF EQUIPMENT DESIRED FOR HYPOTHETICAL SPACE JOURNEY BY AEROSPACE ENGINEERS: 1961 and 1969

Activity	Rank 1961 (n = 80)	Rank 1969 (n = 54)
Books	1	1
Playing Cards	2	6
Musical Instruments	3	9
Record Equipment	4	2
Handicraft Equipment	5	7.5
Art Supplies	6	10
Writing Supplies	7	7.5
Athletic Equipment	8	3
Games and Puzzles	9	5
Photographic Supplies	10	4

$\rho_{xy} = 0.06$

Preferences in present activities for the 1969 group of aerospace engineers were more highly related (0.73, Table 7) to desired equipment in the spacecraft than for the 1961 group (0.56, Table 11). This may mean that people today would not anticipate off-duty activities in space which were very different from their off-duty activities on Earth. This conclusion is supported by the high correlations between stated preferences for current off-duty activities and anticipated equipment usage in the spacecraft discussed previously for the astronauts (0.93), tactical fighter pilots (0.83), and ARPS personnel (0.93). (See Table 7.)

TABLE 11

RANK ORDER OF CURRENT LEISURE ACTIVITIES AND DESIRED EQUIPMENT OF 80 AEROSPACE ENGINEERS (Eddowes, 1961)

Activity	Rank Order of Current Activities	Rank Order of Equipment Desired
Reading	1	1
Cards	3	2
Chess	6.5	3
Musical Activities	2	4
Art	8	5
Athletic	5	6
Puzzles	9	7
Photography	4	8
Gardening	6.5	9

$\rho_{xy} = 0.56$

EFFECTS OF CONFINEMENT ON OFF-DUTY ACTIVITIES

Doll and Gunderson (1969) solicited responses to a "hobbies scale" from civilian, technical administrative, and Seabee personnel prior to a wintering-over period (approximately six months) in Antarctica. During the actual confinement, they twice obtained responses to a leisure time activities questionnaire from the same personnel; once early in confinement, and once later in confinement. Thus, their data provide the opportunity to examine actual leisure time activities as a function of confinement and the duration of the confinement period.

The civilians, technical administrative personnel, and Seabees in the study were asked to respond to the 20 hobby items in terms of their attitude toward each of the hobbies with the possible responses being: "Like strongly, Neutral, and Dislike strongly."

The ranks for the three groups' hobby preference and their spacecraft feasibility are presented in Table 12. Except for those hobbies that are performed outdoors (e. g., hiking), all activities are feasible in the proposed space mission. The rank order correlations between the groups are presented in Table 13. Although the correlations are statistically significant, the strengths of the associations are small and accounts for little of the variance.

The analysis of variance performed on these data indicates that there is a significant difference among hobbies in terms of preferences and furthermore, there is a significant groups x activities interaction. This interaction indicates that for the sample under study, the occupational groupings have some different hobby preferences. It appears that the civilian group differs from the Seabees and technical administrative personnel. The primary differences appear to be stronger interests in classical music, radio gear, photographic

TABLE 12

RANK-ORDER OF HOBBY ITEMS WITHIN OCCUPATIONAL GROUPS*

Spacecraft Feasibility	Hobby	Civilian (n = 148)	Technical Administrator (n = 103)	Seabees (n = 123)
No	Hiking and Camping	1	5.5	3
Yes	Reading Books	2	2	7
Yes	Repairing Things	3	8	1
Yes	Individual Sports	4	3	8.5
Yes	Classical Music	5	14	16
Yes	Reading Magazines	6.5	5.5	2
Yes	Radio Gear	6.5	11	17
Yes	Photography	8	15	14
Yes	Team Sports	9	1	5
Yes	Plays and Dramas	10	16	19
Yes	Popular Music	11.5	4	6
Yes	Models	11.5	12	12
No	Hunting and Fishing	13	9	4
Yes	Movies	14	7	8.5
Yes	Cards	15	10	11
Yes	Painting and Drawing	16	17	18
No	Motorcycles	17	19	15
No	Hot Rods	18	18	13
Yes	Western-Country Music	19	13	10
Yes	Collecting Stamps	20	20	20

*From Doll and Gunderson (1969)

TABLE 13

RANK ORDER CORRELATIONS OF PREFERENCES FOR SEABEE, TECH-ADMINISTRATIVE, AND CIVILIAN GROUPS IN THE ANTARCTIC*

Non-Confined (Hobbies)

	Tech-Admin	Civilian
Seabee	.79	.48
Tech-Admin		.72

Confined (Frequency of Activity)

Early	Tech-Admin	Civilian
Seabee	.94	.80
Tech-Admin		.85

Late	Tech-Admin	Civilian
Seabee	.89	.76
Tech-Admin		.80

Relation Between Early and Late Frequency of Activities**

Seabee	.86
Tech-Admin	.87
Civilian	.87

*Adapted from Doll and Gunderson (1969).

**It should be noted that not everyone who completed the early preference scale completed the late preference scale.

equipment, and plays and dramas by the civilians. The technical administrative and Seabee personnel show greater interest in popular music, hunting, fishing, and movies. There does not appear to be much difference between the Seabees and technical administrative personnel in hobby preferences; however, there is a slight tendency for the technical administrative personnel to have some hobbies in common with the civilians.

During the confinement period the civilians, technical administrative, and Seabee personnel were asked to indicate their frequency of participation on twenty activities. The frequencies were: "Not at all, Few times/month, Once a week, Few times/week, and Every day."

The rank orders of the leisure activities for the Antarctic groups are presented in Table 14. The means and standard deviations of the frequency data for the early and late confinement periods are presented in Appendix A.

The activity findings relevant to the selection of off-duty activities are:

1) The most frequently performed activity was attending movies.

2) Listening to music was also a frequently performed activity. However, there are relevant group differences:

   (a) There was a change toward unacceptability of classical music by the Seabees and technical administratitive personnel during confinement.

TABLE 14

RANK ORDER OF LEISURE ACTIVITY
IN ANTARCTIC GROUPS

Spacecraft Feasibility	Activity	Civilian Early (n=101)	Civilian Late (n=81)	Technical Administrative Early (n=74)	Technical Administrative Late (n=70)	Seabees Early (n=91)	Seabees Late (n=84)
Yes	Movies	1	1	1	1	1	1
Yes	Classical Music	2	3	6	13	6	12
Yes	Popular Music	3	2	3	2	4	3
Yes	Bull Session (Present Job)	4	4	4	4	2	2
Yes	Reading Technical Magazines	5	5	9	8	7	6
Yes	Bull Session (Past Job)	6	7	5	3	5	4
Yes	Reading Fiction	7	6	12	6	14	9
Yes	Bull Session (General)	8	8	10	10	12	11
Yes	Studying Courses	9	9	7	7	10	7
Yes	Writing Letters	10	20	13	18	13	15
Yes	Ham Radio	11	11	8	9	9	13
?	Pool or Billiards	12	16	11	11	8	10
Yes	Western-Country Music	13	12	2	5	3	5
?	"Happy Hour"	14	13	14	15	11	8
Yes	Physical Exercise	15	10	15	12	19	14
Yes	Reading Religious Literature	16	19	17	20	16	17
Yes	Painting and Drawing	17	18	16	17	17	20
Yes	Chess or Checkers	18	14	19	19	18	18
Yes	Cards	19	17	18	14	15	19
Yes	Reading Biography	20	15	20	16	20	16

(b) There was no difference over the confinement period in acceptability of country-western music by civilians who generally had low preference for it, but the frequency of use by the other groups (who initially preferred country-western music) decreased somewhat over the period of confinement.

3) "Bull Sessions" on the subjects of present job, past job, and general topics in that order were frequent activities.

4) Reading material preferences changed over time in confinement. For examples:

(a) Interest in fiction by the Seabees and technical administrative personnel increased.

(b) Interest in biographies increased for all groups.

(c) Interest in religious literature by the civilian and technical administrative personnel decreased.

5) Studying for courses maintained the same relative ranking early and late in confinement for the civilian and technical administrative personnel and increased in relative ranking (but not frequency of performance) for the Seabees.

6) Participation in physical exercise increased from early to late in confinement; however, exercise was still infrequently performed.

7) There was infrequent use of painting and drawing supplies, chess, checkers, and cards by all groups.

8) Although letter writing dropped off during the confinement period, this was probably due to the lack of ability to send or receive mail. It is most unlikely that the decrease in letter writing resulted from a decreased need for personal communication.

The hobby items surveyed during unconfinement (Table 12) were compared with the survey of activities in confinement (Table 14). The questionnaires used in the two surveys were not identical but there were some overlapping items. The correlations between the overlapping items are presented in Appendix A. The results are summarized here.

Hobbies were somewhat predictive of off-duty activities in confinement. However, the correlations were quite low; they were highest for the civilian group. Movies, the off-duty activity participated in most frequently during confinement, was a relatively infrequent unconfined hobby item. Many of the musical preferences during confinement would not have been predictable from hobby preferences prior to confinement. For example, the frequency with which civilians listened to popular music throughout the confinement period would not have been predicted from their preconfinement hobby preferences. Nor would the early listening to classical music by the Seabees and technical administrative personnel.

One of the reasons for relatively low correlations between preconfinement hobbies and activities in Antarctica may have been inadequate recreational facilities during the wintering-over period. This could have accounted for the increased preference for movies. Another example is sports which were a frequently mentioned hobby but appear to have been infrequently performed in confinement (with the possible exception of billiards and pool). Possibly there were inadequate facilities for sports. If so, this may account for the increased participation in physical exercise over the confinement period. The changes in musical preferences could be accounted for on the same basis. If there were inadequate musical facilities, then the particular type of music listened to at any given time would be a function of group musical preference and the relative dominance of groups with one preference over those with others. However, since adequate information on the actual recreational facilities is lacking, the above discussion should be viewed with caution.

The relatively low correlations found between unconfined hobby preferences and actual activities in confinement should be compared to the high correlations found in the current study. In Tables 7 and 8, present off-duty activities and anticipated equipment usage in the spacecraft for the four groups: astronauts, aerospace engineers, tactical fighter pilots, and ARPS personnel were highly correlated. Since the reason for the low correlations found by Doll and Gunderson (1969) for Antarctic personnel is unknown, however, conclusions are difficult to draw. Nevertheless, we would like to make one point. In the Doll and Gunderson (1969) study, movies were an infrequently cited hobby. Its ranking as a hobby was about the same as the ranking it achieved when rated by the astronauts, aerospace engineers, tactical fighter pilots, and ARPS (Table 4) as an off-duty activity. However, when the personnel in the Antarctic study were confined, movies were the most frequently participated in off-duty activity. This should be compared to the low rating of a television set (equivalent to movies) as an anticipated off-duty equipment item in the spacecraft (Table 5). Because of the very high rating of movies in Antarctica and in light of limited knowledge on the actual activity preferences of confined men, more emphasis should be given to TV/movie equipment in the spacecraft recreational facility than its rating by potential crew members would suggest is appropriate.

CONTENT PREFERENCES AND SELECTED ACTIVITIES

The content preferences for the astronauts, ARPS, tactical fighter pilots, and aerospace engineers were essentially similar. The one exception is games and puzzles. Therefore, the data from the four groups were combined. The overall mean and rank order for the content preferences are presented in Tables 15 through 17. Specific preferences for each group are presented in Appendix A. Content preferences are interpreted in relationship to: 1) Leisure activities and equipment preferences; 2) the effects of confinements on off-duty activities; and 3) the spacecraft missions and constraints.

In addition to integrating content preference for selected activities, the section also discusses and selects other likely activities. The bases for other activities are the present and preferred activities of the four current groups, and the activities used by confined individuals (Doll and Gunderson, 1969).

Reading Materials

Reading is the most frequently engaged in present activity for the four groups (Table 4). Books, newspapers, and magazines rank 3, 7, and 8 in the desired equipment area. These would be used a few times a week (Table 5).

The content of present reading is presented in Table 15. As is obvious, most of the desired reading materials require periodic updating. This precludes presenting the media in its conventional form, i. e., as printed matter. It should be noted in Table 15 that we estimate that provision for all the reading materials can be provided to crew members. Most should be provided in a phenomenally equivalent form, e. g., microfilm reader. However, some materials, particularly religious materials, should probably be in book or hard copy form.

TABLE 15

MEAN AND RANK ORDER OF THE FREQUENCIES OF PRESENT OFF-DUTY READING MATERIAL USAGE

Spacecraft Feasibility	Activity	(n = 164) Rank	Mean
P.E.*	News Magazines (e.g., Time, Newsweek)	1	4.12
P.E.	Newspapers	2	3.92
P.E.	Playboy Type Magazines	3	3.77
P.E.	Historical Novels, Short Stories	4	3.70
P.E.	Technical Magazines (e.g., Scientific American)	5	3.68
P.E.	Comic Strips (e.g., Peanuts, Pogo)	6	3.58
P.E.	General Interest Magazines (e.g., Look)	7	3.52
P.E.	Technical Books, Journals	8	3.47
P.E.	Biographical Novels	9	3.45
P.E.	Hobby Magazines (e.g., Popular Mechanics)	10	3.37
P.E.	Science Fiction Novels	11	3.08
P.E.	Mysteries, Detective Stories	12	2.92
Yes	Religious Materials	13	2.71
P.E.	Western Novels	14	2.64

*P.E. = Phenomenally Equivalent, i.e., although the activity cannot be performed with its normal means, we believe we can provide equivalent means.

Since reading changes occur in confinement (Table 14), provision should be made for changes in reading taste. For example, in the space base, where there would be technical personnel, the increase in reading of fiction and biographies should be taken into account. It should be noted that current techniques do not allow prediction of how much and what type of literature should be provided. Therefore, a technique should be developed to permit the designer of off-duty facilities to predict the kind and amount of reading material an individual will require (see Research Requirements).

Listening/Viewing

From all of the findings there is an obvious need to present music, news, sport events, etc. The frequency of attendance of confined personnel at movies is quite clear (Table 14). Identification of the specific movie preferences of crew members is desirable. The same is true of the content of TV programs (Table 16). Again there is a need to develop a technique to permit the identification of an individual's movie/TV requirements in the space mission.

TABLE 16

MEAN AND RANK ORDER OF THE FREQUENCIES OF PRESENT OFF-DUTY TV OR RADIO SHOW OR MOVIE CONTENT

Spacecraft Feasibility	Activity	Rank (n = 164)	Mean
Yes	Sport Events	1	4.25
Yes	News, Weather, Sports Reports	2	4.17
Yes	Educational Shows	3	3.68
Yes	Comedies	4	3.67
Yes	Travelogues	5	3.55
Yes	Mystery or Detective Shows	6	3.50
Yes	Dramas	7	3.32
Yes	Western	8	3.24
Yes	Quiz Shows and Contests	9	2.08

The desirability of presenting sport events, e.g., football games, should be obvious from the contents of Table 16 and 18. Since the crew members of both the station and base will probably both spend many leisure hours watching TV programs, sufficient diversification in the available programs to meet both group and individual preferences must be provided.

In music preference, the Antarctic study (Doll and Gunderson, 1969) indicated differences in music related to occupational groups (Tables 12 and 14). The musical preferences found with the Landis, et al, questionnaire (Table 17) are probably representative of preferences of general types of music for the professional crew members. Because of the large size and diverse composition of the space base crew, conflicting musical preferences will undoubtedly exist. These preference differences could be the cause of considerable conflict. Fewer differences will exist in the smaller and more uniform crew of the space station but some are still expected. To reduce conflicts, it will be necessary to identify both the likes and dislikes of the crew members in music content. These may be used to specify the degree of need for individual listening equipment.

TABLE 17

MEAN AND RANK ORDER OF THE FREQUENCIES OF PRESENT OFF-DUTY MUSIC USAGE

Spacecraft Feasibility	Activity	(N = 164) Rank	Mean
Yes	Popular	1	3.80
Yes	Classical	2	3.78
Yes	Folk	3	3.76
Yes	Jazz	4	3.48
Yes	Electronic	5	2.46

Educational/Study

Studying or coursework was the second most frequently performed present off-duty activity for the four groups (Table 4). It also ranked third in the content preference for TV/Radio (Table 16). Furthermore, next to reading fiction and technical magazines, it was the most frequently performed activity for the three groups in Antarctica (Table 14). Thus it would be desirable to provide adequate opportunities for studying.

Because of the mission length (3 - 6 months), it would not seem unreasonable to have formalized instruction. This either could be provided by communication with Earth or by audio-visual cassettes or by one or more crew members in the spacecraft. Alternately, interest in engaging in educational/study activity could be met by correspondence courses or by writing a dissertation or technical paper.

Exercise

The highest ranked equipment desired for the space mission off-duty facility was that necessary for physical exercise (Table 5). Viewports exceeded it but are not equipment per se. Physical exercise is a frequently engaged in activity by the four groups (Table 4). They presently engage in exercise a few times a week. However, the Antarctic personnel exercised somewhere between a few times a month to almost weekly.

Only two types of exercise activities are presented in Table 18. They are jogging (7th out of 10) and calisthenics (10th). Obviously, more information is required about the types of exercise desired by potential crew members.

In discussing the sports and exercise preferences of the astronauts with Musgrave (Personal Communication, 1969), it was found that

1) competitive activities are enjoyed by astronauts (handball and squash are frequently used activities); 2) there is preference for exercise equipment that moves (e.g., weights); 3) the Exergeni is not frequently used; 4) feedback is desired (e.g., ergometer with speedometer); and, 5) exercise is considered work and the addition of motivational aids that ignore this will probably not be effective.

The need for an exercise program in a zero or reduced gravity environment is obvious. The desirability of an exercise facility that individuals would be motivated to use is equally obvious.

TABLE 18

MEAN AND RANK ORDER OF THE FREQUENCIES OF PRESENT OFF-DUTY EXERCISES AND SPORTS

Spacecraft Feasibility	Activity	(n = 164) Rank	Mean
No	Football	1	4.15
No	Swimming	2	3.97
P.E.*	Handball	3	3.77
No	Basketball	4	3.64
No	Golf	5	3.58
No	Baseball	6	3.53
P.E.	Jogging	7	3.37
No	Auto Racing or Horse Racing	8	3.31
No	Ice Hockey	9	3.29
Yes	Calisthenics	10	3.02

*P.E. = Phenonenally Equivalent, i.e., although the activity cannot be performed with its normal means, we believe we can provide equivalent means.

Sports

Sports are frequently performed (a few times a week) by the current four groups (Table 4) and by the Antarctic personnel (Table 12). However, establishing adequate sports from the sports preferences in Table 18 is difficult. None of the sports listed in the table can be performed as they are on Earth when in either spacecraft. However, as indicated in the table, it may be possible to develop a sport phenomenally equivalent to handball. The solution to this problem possibly lies in the creation of sports that capitalize on the reduced gravity, confined environment.

Other Activities

Additional off-duty activities were identified from evaluation of: 1) the present and anticipated activities of the current four groups (Tables 4 and 5); and 2) activities actually performed in confinement (Table 14). These include: family activities, religious activities, being alone, building models, resting and relaxing, eating snacks, technical writing, personal writing, personal communications, "Happy Hour", painting, sculpting, photography, playing musical instruments or singing, repairing things, and collecting stamps and coins. The activities are listed in the relative rank order of use and preference. Many of the lower ranked activities are highly individualistic and some would be difficult to provide. It is recommended that these lower ranked activities be given lower priority and considered for inclusion only if specifically desired by one or more crew members.

Some of these activities require further discussion:

Job Related Activities. One possibly overlooked off-duty activity is the individual's job. As shown in Table 14, it is presently performed a few times a week. Therefore, job related activities or auxiliary projects may be a favorite off-duty activity.

Obviously, supplies for these job related activities would create additional requirements. Because of the limited volume in the recreation facilities, work stations could be used for off-duty participation in job-related activities. Use of the work station site as an off-duty site would also enable the crew member to be separated from other crew members.

Personal Communication. Family activities ranked third in present activities (Table 4). Therefore, some means of communication with family, friends, and professional acquaintances appears desirable.

If one considers "bull sessions" as personal communications, then there is an obvious need (Table 14) to provide a relaxing atmosphere for such sessions. (There might be an equally important requirement to permit crew members who want to be alone to get away from such sessions.)

Religious Activities. Religious activities were performed up to once a week by the current groups (Table 2); for Antarctic personnel, the reading of religious material was relatively infrequent (Table 14). As a matter of fact, religious reading in the Antarctic group was bimodal in use, individuals either read religious material weekly or not at all. The above two facts probably indicate that we have information on two aspects of religious activity. The first is probably related to attendance at religious services while the latter is strictly related to religious reading. Still unknown are: 1) the need for specific religious activities, e.g., Sunday services; 2) specific religious reading materials; and 3) the acceptability of the means (e.g., microfilm reading materials) to provide for religious activities.

Being Alone. One difficulty for people in confinement is the necessity of constant contact with the same people and the same environment. Most individuals in confined quarters have a need to be alone.

It is therefore desirable to provide individuals with activities and facilities that would permit them to "get away" from others in the spacecraft. Looking out at space, personalized studying, doing nothing in a private chamber, and working alone during the off-duty time are some possible activities that would permit a crewman to be alone.

SUMMARY OF SELECTED ACTIVITIES

Based upon our analysis of preferred activities and equipment and the influence of confinement, the approximate frequency of anticipated activities for the advanced space missions are:

Daily

Watching TV shows
Listening to popular music

A Few Times a Week

Reading newspapers (magazines)
Watching news, sports, weather reports
Doing nothing
Physical exercise
Eating snacks

Weekly

Studying
Looking out at space
Listening to classical music
Job related activities
Watching sports shows
Personal (family) communication
Playing sports
Watching movies on TV

A Few Times a Month

Reading fiction
Watching educational shows
Reading technical books
Watching travelogues
Watching comedy
Being alone
Listening to folk music

Monthly

Playing cards
Personal (friends) communication
Playing chess/checkers
Personal writing
Watching detective shows
Listening to jazz music
Technical writing
Reading biographies
Repairing something

Less Than Once a Month

Watching drama
Watching westerns
Building something
Reading religious materials
Religious activities
Playing musical instruments
Photography
Personal communication (professional)
Playing board games

The above frequencies are primarily applicable to the professional personnel. The listing is not predictive of a particular individual's preferences. These have to be determined by detailed analyses of off-duty preferences of specific crew members.

CHAPTER IV

EQUIPMENT REQUIREMENTS

INTRODUCTION

This chapter develops the equipment requirements to support the off-duty activities which have been identified previously. By "equipment requirements" is meant the characteristics which the equipment should have to best support suggested off-duty activities. It does not mean that specific types of equipment are identified.

In some cases, several approaches to equipment requirements are identified. The alternatives can be used in selecting the particular equipment.

The equipment requirements have been grouped into five general areas. These are:

1) Audio-visual (supporting five types of activities: Music/Radio, Reading, TV/Movies, Education, and Personal Communications).
2) Games.
3) Sports.
4) Exercise.
5) Other (incidental equipment requirements such as tables, chairs, etc., or their equivalents).

In general, it was found that separate consideration of equipment requirements for the space station and space base was not necessary. The exception was in the area of sports. Here, the differences between the zero g environment anticipated on the space station and the

0.3 g environment anticipated on the space base will have considerable impact on the sports which may be performed and hence on the equipment requirements. Therefore, sports was treated separately for the two types of missions.

AUDIO-VISUAL

One audio-visual system can provide for reading, viewing, and listening activities (Fig. 5). From preference findings and spacecraft constraints, four criteria for its design were stated. These are:

1) The system must satisfy group preferences.
2) The system must satisfy individual preferences.
3) The system must satisfy changes in individual and group preferences over time.
4) The system must maximize flexibility of equipment use.

The latter three criteria deserve further comment here. Concerning criterion 2, it should be noted that individuals may differ in preference in two ways. The first way is difference in the particular activity each individual wishes to pursue. To handle this difference, the effects of the equipment for each activity should not extend beyond the immediate user (e.g., sound should be restricted to the individual listener). The second way is difference in preference for content (e.g., some people prefer folk music while others prefer classical) rather than differences in the particular activity to be pursued. Content differences may be handled by providing a number of pieces of like equipment, each of which allows content selection by the individual user.

The third criterion, satisfaction of individual and group preference changes over time, requires that the system be dynamic. A communication link with Earth is recommended. This would permit a dynamic audio-visual system. The link does imply a constraint;

Activities

Music/Radio
Reading
TV/Movies
Education
Personal Communication

Criteria

Satisfy Group Preferences
Satisfy Individual Preferences
Satisfy Changes in Preferences

Functional Requirements

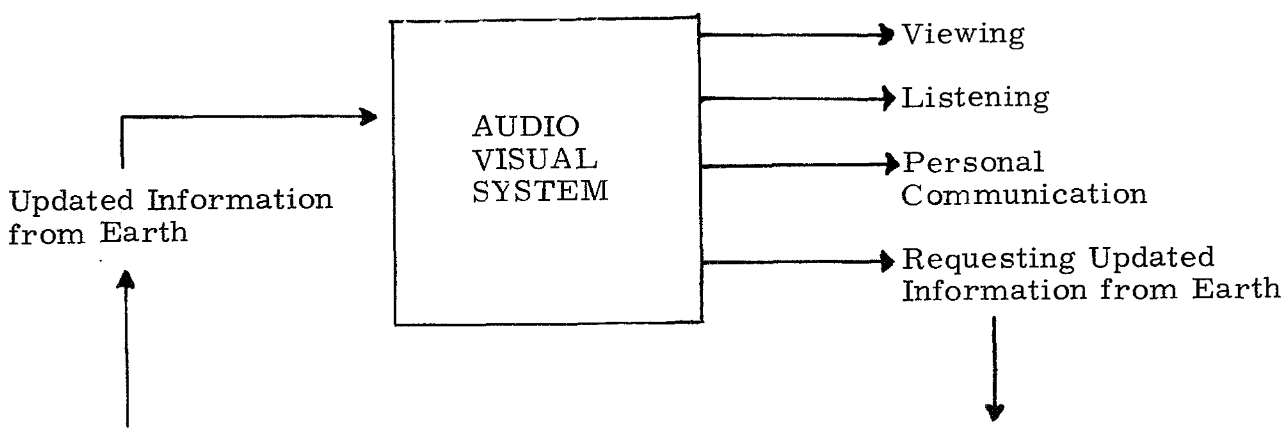


FIG. 5. FACTORS CONSIDERED IN SELECTING AUDIO-VISUAL SYSTEM.

namely, equipment must be selected to permit efficient interface with the communication link. However, the link provides the greatest flexibility and the broadest possible scope for preference changes with time (compared, for example, to dependence on resupply shuttles for provisions of new materials).

The fourth criterion, flexibility of the audio-visual facility, aids in meeting the first three criteria. Flexibility requires a storage medium which can accommodate all of the different types of materials. The most flexible storage medium currently available is magnetic tape. It can store music, television, and alphanumeric information--all necessary for the audio-visual system.

For ease of handling, especially in zero gravity, the magnetic tape should be enclosed in a cartridge. Several manufacturers are presently developing a magnetic tape cartridge for the consumer market which can store a one-half hour television program. Each cartridge occupies about 0.03 cubic feet of volume and weighs about one-half pound. The cartridges can be used to store materials other than television programs; for example, a cartridge can store 7 to 8 hours of stereo music or more than 500 pages of written matter. However, further development of the cartridges is required to permit recording at high speeds.

The following sections treat the separate activities which the audio-visual system will provide. These are: music/radio, reading, television/movies, education, and personal communication.

Music/Radio

Music, according to both preference data and actual confinement studies, is one of the most desired off-duty activities. However, subjecting an individual to music he dislikes is worse than providing him with no music at all. For this reason, the equipment must insulate individuals from others' musical tastes. This implies multiple sources and output devices; unfortunately, the available questionnaire data does not permit specific numbers to be recommended for crews of given size and composition.

Although radio ranks in the upper half of desired off-duty equipment in space (Table 5), the reason for this ranking is unclear. If radio is primarily regarded as a music source, then there are more efficient and higher fidelity solutions. If current information is desired, then other means would be better (e.g., news broadcasts could easily be relayed to the space vehicle). Neither reason justifies radio as a high priority item for inclusion in the recreation facilities.

The most obvious source for music is magnetic tape. As the tape can be re-recorded with different music, the music can be changed to satisfy changing tastes caused either by changes in crew complement or by the effects of confinement. There should be sufficient tape playing equipment so that crewmen with differing musical tastes can exercise these tastes without conflict.

Designing the music devices to maximize flexibility is very important. The basic output device should incorporate a modular tape player--amplifier unit. This "music module" should be usable at several places in the spacecraft. It should incorporate a power supply, tape player, and low power amplifier. The amplifier should have sufficient power to drive a headset or small speaker for private listening. It could easily be carried to the sleeping area or other locations. For output devices which require higher power, the music module output would serve as the input to another amplifier.

The music module could be quite compact. Reduction in size is limited by the form in which the magnetic tape is supplied. As previously mentioned, the tape should be supplied in cartridge form. The best estimate of cartridge size is about 0.03 cubic feet in volume. For this size cartridge, it should be possible to design the module to occupy about 0.15 cubic feet. The module dimensions could be about 10" x 4" x 6" with a weight of two to three pounds, not including the cartridge.

For group listening, a pair of speakers should be provided for stereophonic sound. These should be located wherever groups are likely to congregate. Because of the higher power required for these larger speakers, the output from a music module would be amplified by another amplifier.

Headsets should be provided for personal listening. They can take advantage of the portability of the music module. These should be carefully selected for comfort and sound fidelity if they are to be used for sustained periods of listening.

The "personal chamber", an enclosed area for individual activities, also provides for personal listening. Reading, listening to music, watching television, talking to family or friends back on Earth, and studying are among the possible activities.

The first attempt at providing a personal chamber was the "womb chair" shown in Figure 6. The chair capabilities include stereophonic sound, lighting, sun lamp, and a mount for supporting either a television set or a microfilm reader. All of the activities possible using the audio-visual equipment are included.

The possible advantages of constructing the chair of inflatable materials were examined. This led to the development of the personal chamber illustrated in Figure 18 (Chapter V). The resulting inflatable chamber is stowable in only a small percentage of its deployed volume.

Reading

Of the reading content areas, those ranked highest have one characteristic in common; they require a supply of current, up-to-date materials.

The resupply interval determines the method of supplying current material within a given content area. With a resupply interval of thirty days, newspapers, and weekly news magazines for the space base must be electronically transmitted if they are to be current. For the space station, monthly magazines and journals must also be transmitted as the resupply interval is expected to be either ninety or 180 days.

Electronic transmission at the level and volume required to maintain currentness of written information for both space station and space base is within the state of the art. The alphanumeric information could be placed in almost any format. It could then be transmitted to the space vehicle at high speed and recorded on a tape cartridge.

A number of output equipments are available which might be used to display the transmitted information. The information can be displayed on a television screen, placed directly onto microfilm, or printed out by a typewriter. Depending upon the constraints of a particular mission, one or more of the output devices might be selected for various types of information.

A character generator, available from several manufacturers, would convert the alphanumeric information into characters displayed on a television screen. The written information would simply replace the normal input and be displayed a half page at a time. The displayed information could be changed either by pushing a button for a new half page or by the print steadily moving upward on the screen.

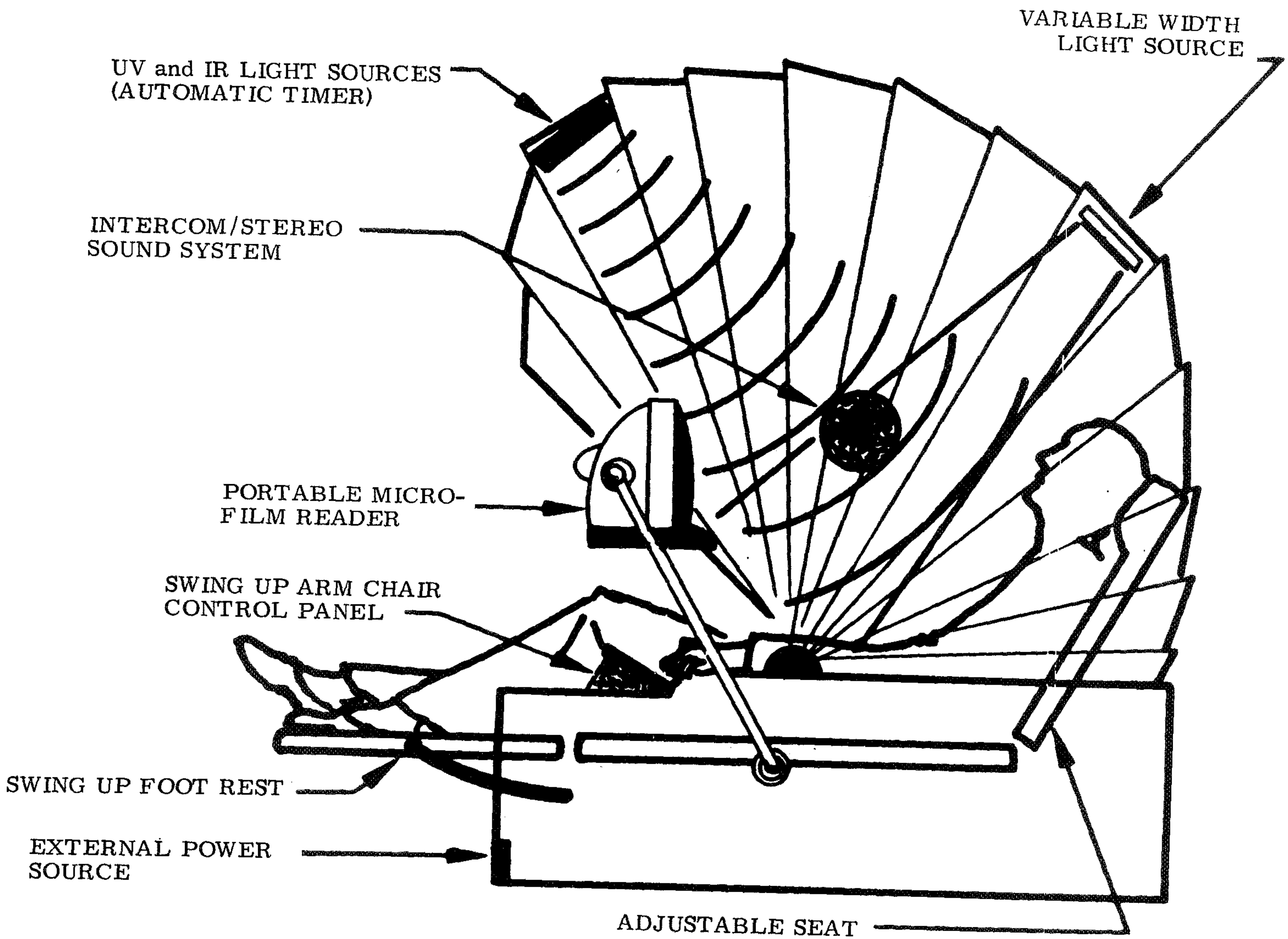


FIGURE 6. PERSONAL CHAMBER FOR INDIVIDUAL AUDIO-VISUAL REQUIREMENTS

Written information could be placed directly onto microfilm. An example is film manufactured by Kalvar Corporation, which is developed by heat. The film could be exposed by light diodes or a laser beam. The technology to produce a unit meeting the necessary constraints should be available within two years (Bernstein, 1969).

Typewritten output currently has the highest legibility but the distinct disadvantage of requiring large supplies of paper. If it is possible to develop paper or inks that would permit the paper to be reused, typewritten presentation of transmitted information would be much more acceptable. A typewriter might also be developed that automatically feeds individual sheets of paper into the mechanism so that written material could be produced in book/magazine format. Alternatively, a standard electric typewriter using paper rolls could produce hard copy which could be packaged as scrolls.

The acceptability of the various devices for presenting written information may vary with the kind of information; e.g., newspapers may be most acceptable if displayed on a television screen, news magazines on paper, and monthly magazines on microfilm. More information is needed on this subject.

For books, selection of audio-visual media is not difficult. Microfilm is an obvious solution. It is available in several formats and in several information densities.

There are two forms of microfilm, film and fiche. The film form is available in cartridges holding 5000 pages. The fiche is available with 3200 pages on one 4" x 6" film. Further increases in information density are expected over the next few years. However, as the information density increases, the legibility decreases. Additionally, the rear projection characteristic of most microfilm readers tends to promote glare and eyestrain. Both of these effects decrease the acceptability of microfilm.

Although microfilm is an obvious solution, crew acceptability of books on microfilm requires further research. Consideration should be given to the advisability of quantifying the legibility standards for microfilm readers. If this were done early in the development program for the space station/base, the clear standard available to manufacturers would insure the production of acceptable equipment.

Present limitations on legibility occur in both the filming and enlarging operations. Both of these operations employ optical techniques. Improvements could result through the application of electronics. The film could be printed using a laser beam, enlarged using television circuitry. Substantial technological gains can be expected in both the optical and electronic methods during the next few years (Bernstein, 1969).

According to industry sources contacted, the requirements for microfilm devices should be frozen about one year prior to launch to enable production and testing. If electronic methods are superior to optical then requirements should be frozen two years prior to launch.

Movies/Television

Movies and television are highly desired off-duty entertainment, based upon actual utilization of confined personnel in Antarctica. Accordingly, we have placed a high priority on developing means for providing for this kind of audio-visual entertainment.

While movies are a desirable source of off-duty entertainment for men in confinement, they will be impractical for use on the space station. The three-to-sixth months resupply interval will impose too great a weight and volume penalty if sufficient numbers of movies are provided to prevent excessive repetition.

The thirty day resupply interval for the space base makes movies feasible. They may be physically transported by the shuttle. At present, the most suitable format for the movies is super-8 film. By 1975, however, film technology will probably have progressed sufficiently to provide higher information density with equivalent visual quality. Firms contacted indicate that one year would be sufficient to provide a suitable projector and six months to provide the prepared film.

Television could be provided for the crews of both the space station and space base. On the space station, it would substitute for movies; on both it would meet many of the requirements for current information.

The ability to provide television programs to orbital vehicles is presently state of the art. The most useful unit of television programs is a one-half hour program; that is, twenty-four minutes exclusive of commercials. Television bandwidth for a 550 line signal is 2 kc. State of the art in transmission and reception is presently about 6 kc. Therefore, a 550 line television program can be sent at three times normal speed; in other words, a twenty-four minute program can be transmitted in eight minutes. The station/base will be line-of-sight for 8 to 15 minutes. Movies or longer programs would therefore require several sequential transmissions to provide the total program material for the crew.

Mission planners are presently considering a relay station which would permit constant communication with Earth. This will eliminate most of the necessity for high speed transmission. However, optimization of the communications link may still require high speed transmission.

Personal Communication

Provision for contact with friends and relatives on Earth is recommended as an aid to reducing the effects of confinement upon crew members, especially those manning the space station. For these individuals, who will have direct contact with only a few other individuals during a period up to six months, a means of private communication is particularly desirable.

Patching a communication link from the space station into ground telephone lines would be an ideal means of providing personal communication; the crewmen could then place calls almost at will. If used, frequent contact with family and friends might forestall many of the adverse effects of isolation. Scrambling the signal until it enters the telephone lines to provide privacy is recommended.

Another possibility for personal communications is a typewriter keyboard with a character generator. The individual crewman could type letters or other messages and send them back to Earth where they could appear as a standard teletype or electric typewriter output. The reason for the character generator is that the letters would appear on a television screen as they were typed and could be corrected if desired. The typing would then be placed on magnetic tape and transmitted to Earth.

Education

The above typewriter keyboard and television set could connect the spacecraft with a time sharing computer on Earth. This could make computer-aided instruction available to the crew. This capability would require only a small portion of the communication link to Earth. [1]

The communication links could also serve other educational/ professional pursuits. A crew member who was writing a dissertation or technical paper could send it to Earth. Crew members could engage in correspondence courses, etc.

GAMES

The question of which games should be supplied for the crews has received a great deal of attention from everyone who has worked in this field. With the preference data from the astronauts and related groups, plus data on actual confined groups such as those in Antarctica, this great emphasis on games is difficult to understand. Only in the data from Eddowes (1961) have any activities classifiable as games ranked higher than the lower third of possible activities. All other available data indicate that many other activities are preferred to games. However, games should still be considered because of the diversion they may offer with low weight and volume penalties.

In this study, games were classified into six categories on the basis of the primary element of the game. From the data available, it is possible to rank these categories and establish some measure of relative desirability within the games area.

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[1] In discussing the audiovisual system, many activities have been suggested which would be best supported by a communication link. Undoubtedly, those concerned with the development of facilities other than the recreational facilities are also planning to use the link. To ensure development of adequate design requirements for the link, estimates of planned utilization by all facilities should be obtained. If the link cannot be developed to accommodate all users fully, groups planning the different facilities should be informed of the limits of link usage they will be allowed, so that alternate means to support some activities may be selected.

The first and most highly desired of the game categories among persons similar to those likely to be selected as crew members is games which emphasize motor skills. These games include ping-pong, pool, Hit-the-Spot, Frisbee, Space Maze, darts, various target games, and many others. Of these, ping-pong is easily the most preferred.

Means have been suggested for modifying ping-pong for zero gravity (Landis, et al, 1969) and cursory examination suggests that ping-pong could be played directly in the 0.3 g space base. However, there are some changes in the game that will occur if ping-pong is attempted in the spacecraft which may have greater effect than might be first thought. The primary change occurs in the ball's flight path. The density of the air in the space vehicle is approximately half that of Earth. This will increase the speed of the ball and change the shape of the curve the ball follows. Any spin applied to the ball while striking will have a lessened effect because of the lowered air pressure. These effects could be reduced by providing a larger ball than normal on Earth. However, merely enlarging the standard ping-pong ball would alter other characteristics; e.g., bounce. In zero gravity, the ball would not curve, except from spin effects. In 0.3 gravity, the ball would drop only 30% as fast as it does on Earth; the ball's path would change drastically. If anything could be more carefully designed to frustrate a ping-pong enthusiast, we cannot think of it.

Although it is possible to adopt one or more of the various motor skill games to the environmental conditions of the space station/base, it is doubtful if there will be sufficient return to justify much effort. It might be useful to include motor skill tests within the recreational facility to provide "game" opportunities. Target games employing darts either thrown or propelled by compressed air would be enjoyed, especially if a moving target were provided.

Games which are based on strategy are the second choice of the astronauts and relatable groups. These include chess, checkers, Go, Stratego, Qubic, Score-4, and others. These games are among the easiest to modify for use in zero gravity, indeed, several of them are sufficiently popular on Earth that they are already commercially available in acceptable form. Several of these games should be included in each facility because of the ease of inclusion and the relatively high preference rankings.

Third in the preference rankings among games are those based primarily upon vocabulary. These games include Foresight, Probe, Scrabble, RSVP, and others. It would be useful to include one of these games in the specification for each of the facilities; probably Scrabble, as it is already available in a suitable form.

Next in the ranking of games are those based upon chance. Few of these games depend exclusively upon chance, but this is the primary factor. In the questionnaire, this category is expressed as card or dice games. In some games of this type, luck (with cards or dice) controls the progression of the player through some hypothesized set of circumstances. It would be useful to include several decks of cards within each facility in view of the low weight and volume required. Racks could be made to hold the cards in the zero gravity facility.

The categories of puzzles and miscellaneous hobbies come last on the list of game preferences. While these rank quite low among the types of games, certain hobbies may rank quite high among off-duty activities for individuals. Therefore, we suggest that each individual crewman be given a limited amount of discretionary choice for the inclusion of specific activity items.

SPORTS

As indicated in Table 19, none of the preferred sports can be performed in the proposed spacecraft. New sports appropriate to the environment are required. However, to attempt to provide the crew members of either the space station or space base with descriptions and rules for a variety of original sports is not a worthwhile endeavor. Sports evolve; they begin with an original idea which later undergoes a series of elaborations and modifications. The changes make the evolving sports both more competitive and fairer. Additionally, we expect that the crewmen will find the development of new sports an enjoyable activity in its own right.

Sports, by definition, are competitive. They may be directly competitive (as between two people for a single, unsharable reward) or indirectly competitive (comparision of the progress of two people toward a standard of perfection). Directly competitive sports generally employ the occurrence of an event as a scoring method; one side attempts to bring about the occurrence of the event, the other to prevent it. Indirectly competitive sports generally involve attempts by an individual or a group to improve over past performance. Thus, competition may be between individuals or between groups; direct or indirect.

The two ways of classifying sports given above may be combined to form four categories of sports. These are: direct/individual; indirect/individual; direct/group; and indirect/group. In Table 19, the sports activity preference of astronauts and scientist-astronauts (as indicated in their biographies) have been classified under these categories and have been evaluated for their feasibility in the spacecraft. From examination of this table it is apparent that when the astronauts mention sports, they mean individual sports.

TABLE 19

ACTIVITY PREFERENCES OF ASTRONAUTS AND SCIENTIST-ASTRONAUTS *

Directly Competitive Individual Sports	Scientist Astronauts	Astronauts	Total	Spacecra Feasibil
Handball	3	15	18	P. E.
Tennis	2	3	5	No
Squash	2	2	4	P. E.
Badminton		1	1	No
Paddleball		1	1	P. E.
	7	22	29	
Indirectly Competitive Individual Sports				
Water and Snow Skiing	4	13	17	No
Hunting and Fishing	3	13	16	No
Swimming	3	12	15	No
Boating and Sailing	9	6	15	No
Golf		9	9	No
Scuba Diving	3	3	6	No
Hiking	3	1	4	No
Bicycling	2	1	3	P. E.
Gymnastics	2	2	2	P. E.
Bowling		2	2	P. E.
Running		1	1	P. E.
High Bar Exercise		1	1	No
Soaring		1	1	No
Mountain Climbing	1		1	No
Parachuting	1		1	No
Weightlifting	1		1	P. E.
Surfing		1	1	No
	29	67	96	
Directly Competitive Group Sports				
Baseball	2		2	No
Soccer		1	1	P. E.
Ice Hockey	1	1	2	No
Volleyball		1	1	No
Basketball		1	1	No
	3	4	7	

Indirectly Competitive Group Sports

(None identified as preferred activities.)

* Taken from Astronauts Biographies.

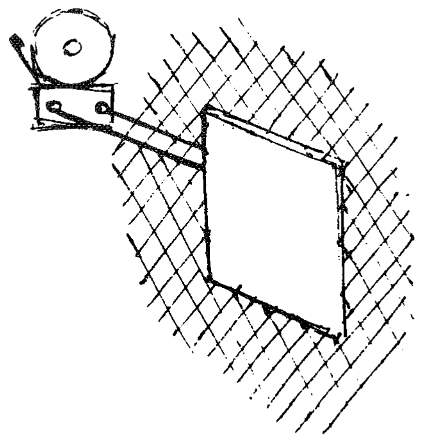
The next two sections consider sports in the space station and the space base.

Space Station

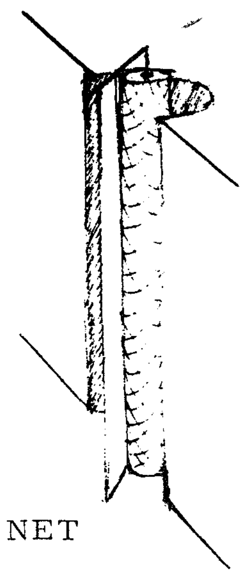
A major problem in the space station is prevention of conflict between sports and other activities being undertaken simultaneously in the same compartment. A physical barrier will be required to establish the boundaries of the sports area. The multi-use nature of the recreational facility suggests that the barriers should be either deployable or movable or both. The suggested solution is a pair of nets, each $6\frac{1}{2}'$ x $9\frac{1}{2}'$ and each of a weave (e.g., hole size) suitable for grasping. The attachment for the nets should permit varying the tension (and therefore the elastic characteristics) of the nets. This would facilitate a variety of uses (e.g., ball return, tumbling, trampoline, etc.). The nets would be stored within the wall, deployable by one man in a variety of configurations (Figure 7).

The nets could be placed as far as eleven feet apart along the diameter of the compartment. This distance would be suitable for tumbling (Dunkley, Personal Communication, 1970). In conjuction with other pieces of equipment, sports phenomenally equivalent to those enjoyed on Earth could be enjoyed in the space station.

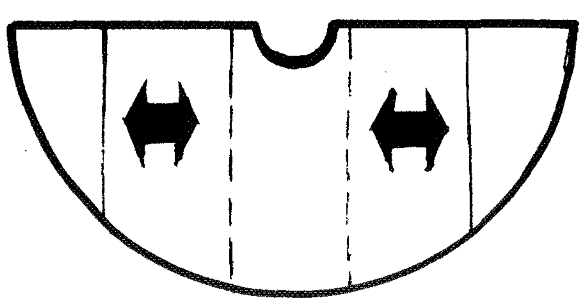
The crew should be provided with a kit that is designed to permit development of sports in zero gravity. The kit should include several different sized balls, paddles or rackets, tape to permit marking necessary boundaries, and some targets. This kit should permit enjoyment of any sport which is directly adaptable from Earth and support the development of completely new sports.



SCORING SENSOR



DEPLOYABLE NET



MOVABLE NETS

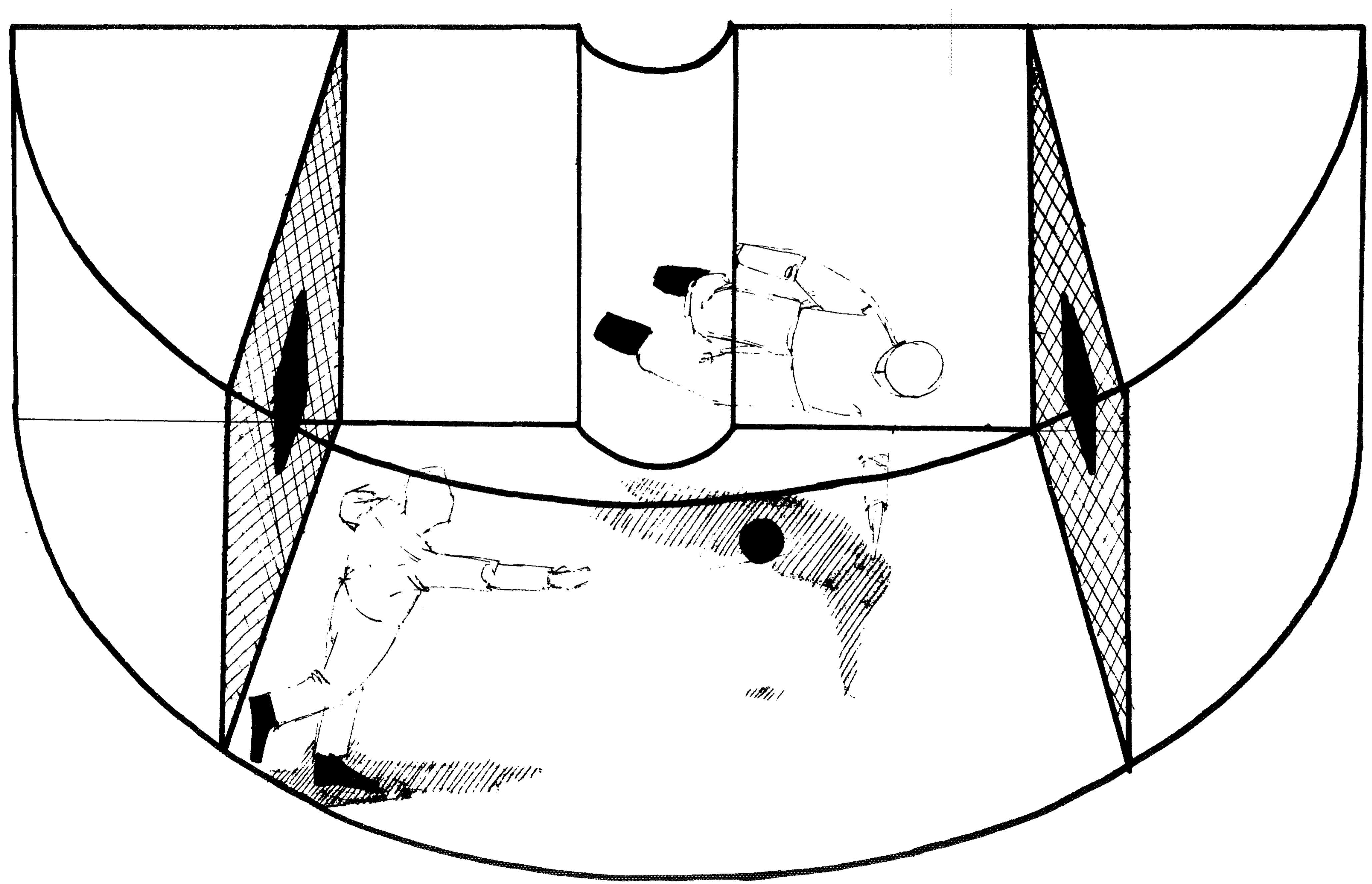


FIGURE 7. SPORTS FACILITY CONCEPTS

The balls should be supplied in several sizes and weights; most larger and heavier than on Earth. Appropriate sizes and weights should be determined through experiment (e.g., in the KC-135). When the crewman attempts to throw or strike one of the heavy balls, his body will react and the path of the ball in the new environment will have to be learned. How long this novel effect will last is unknown.

A smaller ball may be used in sports similar to handball or squash. Deck tennis rackets should be directly usable in the confined environment of the space station.

The larger ball, similar in size to a medicine ball, could be used in a sport similar to soccer. Targets could be placed on each net and the participants could attempt to make the ball strike their opponents' target without using hands or forearms. This game might be suitable for four or more participants, depending on their ability to operate in such a confined area in zero gravity.

All balls should be supplied with electrically conductive surface. Fabric targets with wire woven in them may then be employed. Contact of the ball with the wires would complete an electric circuit. A bell or light could be used to indicate that contact had been made. The targets should be supplied in varying shapes and colors to assist orientation.

Space Base

Providing for enjoyable sports is more difficult in the space base. The orientation of the force providing artificial gravity results in only a six and one half foot floor to ceiling distance. This drastically limits sports activities.

Even under Earth gravity, most reasonably athletic men could jump with sufficient force to bump their heads violently against the ceiling. Because of the reduced gravity, anyone over six feet tall would bump his head if he walked as if he were still on Earth. Clearly, the ceiling must be padded. However, the space required for the padding will reduce the floor to ceiling height and thereby will increase the number of contacts between head and ceiling. As some of these contacts may be violent, we recommend that the floor be padded also to reduce injuries from falling. With conventional athletic padding on floor and ceiling, the reduction of floor to ceiling height will be about one and a half inches.

Another effect of the limited floor to ceiling height is the restriction of overhead arm movements. Even the ten percentile man (5'4" tall) would strike his hand against the ceiling if he attempted to swing his arm over his head. A six foot man would be able to fill the space between his head and the ceiling with the width of his hand. This constraint is demonstrated in Figure 8, which shows a six foot man in a six and one half foot room.

Any attempt to provide sports for the space base facility must incorporate many of the same practices recommended for the space station facility. The same type of spring return net mentioned earlier is the most feasible means of providing a sports area. These nets would again be deployable and movable. The tension would be adjustable by a ratchet and crank to permit controlling the speed of rebound.

Handball, squash, and paddleball are examples of the games possible under these conditions. It is doubtful if even these games would be enjoyable. Also, the area for sports must at all times give way to the requirement for exercise; this further restricts the probable floor area available for sports. To put the space available in perspective, the portion of the space base (one of the two compartments) which must accommodate all sports and exercise for 50 to 100 men is equivalent

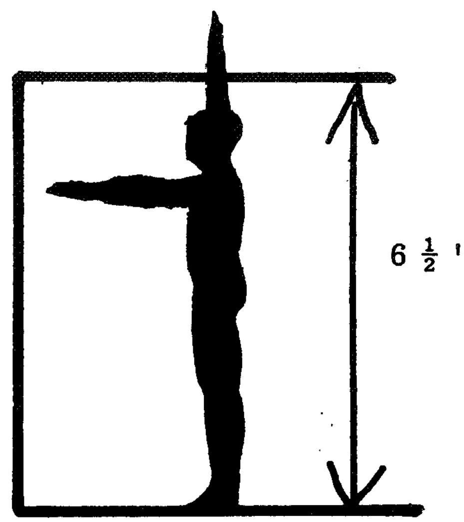


FIGURE 8. POOR "FLOOR" SELECTION

to 40% of the floor area and 11% of the volume of a handball court. These figures indicate that only a few out of a crew of 50 to 100 men will be able to engage in sports simultaneously.

We doubt that there is a practical solution to sports with the six and one half foot floor to ceiling height and recommend that the height of the sports facility be extended. Because of the modular construction of the space base, this extension should be another module; for a total height of thirteen feet.

EXERCISE

Two aspects of exercise in the recreational facility are dealt with in this section. The first is exercise equipment requirements, per se. The second is motivation of crew members to exercise.

Exercise Equipment Requirements

Lack of exercise on Earth or in short periods of reduced gravity results in loss of muscle tone and cardiovasculr deconditioning. Other biomedical effects occur with bed rest or in zero gravity. However, the effects of inadequate exercise coupled with long periods in a low or zero gravity environment are unknown. It is expected that effects will be magnified by some unknown amount.

Because of the lack of quantified exercise program requirements, the following functional specifications for exercise equipment were developed:

1) Use would maintain or increase crew member cardio-pulmonary functions.

2) Use would maintain or increase crew member muscle tone over time.

3) Use would maintain or increase muscle tone and cardio-pulmonary function efficiently (e.g., exercise with maximal effect for minimal amount of time spent exercising was sought).

Manufacturers of exercise equipment were contacted with a form letter describing the problem and asking for catalogs. Most responded with catalogs; in addition, some offered assistance. The catalogs were examined to determine the approaches to exercise intrinsic to the equipment design.

Two approaches were identified. The first was to attempt to exercise all muscles of the body simultaneously. This is exemplified by bicycle ergometers. The second approach is to exercise the muscles a group at a time. This approach is optimized in peripheral heart action programs.

The unit made by Exercycle Corporation is a type of bicycle ergometer. It is a motorized device with both bicycle pedals and movable handlebars. The exercise is accomplished by attempting to speed up the movements of the pedals and handlebar over the pace set by the motor. This type of exercise device has received wide acceptance, especially where space is limited. Gillingham and Hunsicker (1967) reported significant cardio-respiratory improvement with fifteen minutes daily use of the device in a submarine over a two month period.

Bicycle ergometers which are not powered are preferable to motorized versions for use in space because of the power and weight savings achieved by eliminating the motor. However, these have somewhat different characteristics from the motorized Exercycle. One difference is that the handlebars do not move. Olree (Personal Communication, 1970) is presently investigating this type of exercise device. His interim results indicate that twenty minutes a day, five days per week at 80 to 85% of maximum heart rate will maintain satisfactory cardiovascular-respiratory fitness for astronauts. Olree adds, however, that the device and exercise program maintain muscle tone only in portions of the body. Additional resistive exercise is necessary to maintain muscle tone throughout the body.

Peripheral heart action programs adjust the order and effort required for resistive exercises to raise and maintain the heart rate at a particular level. Each exercise set begins with the major muscles of the legs to raise the heart rate quickly. Subsequent exercises require different muscle groups. The same muscle group is not exercised twice in a row but only after a different muscle group or groups have been exercised. The set of exercises is repeated as many times as necessary to meet fitness goals. Some possible exercises are shown in Figure 9.

The particular resistance device used for peripheral heart action training is not critical. Any device which permits the order and expenditure of effort required would be suitable. On Earth, the program normally employs weights. Other devices would obviously be necessary for zero or reduced gravity.

The Exergeni has already been used in space flights. This is a resistance device employing a cord pulled through a variable resistance. Olree is investigating this device also. To date, its use has failed to yield cardio-pulmonary conditioning. However, another test, presently beginning, may show better results.

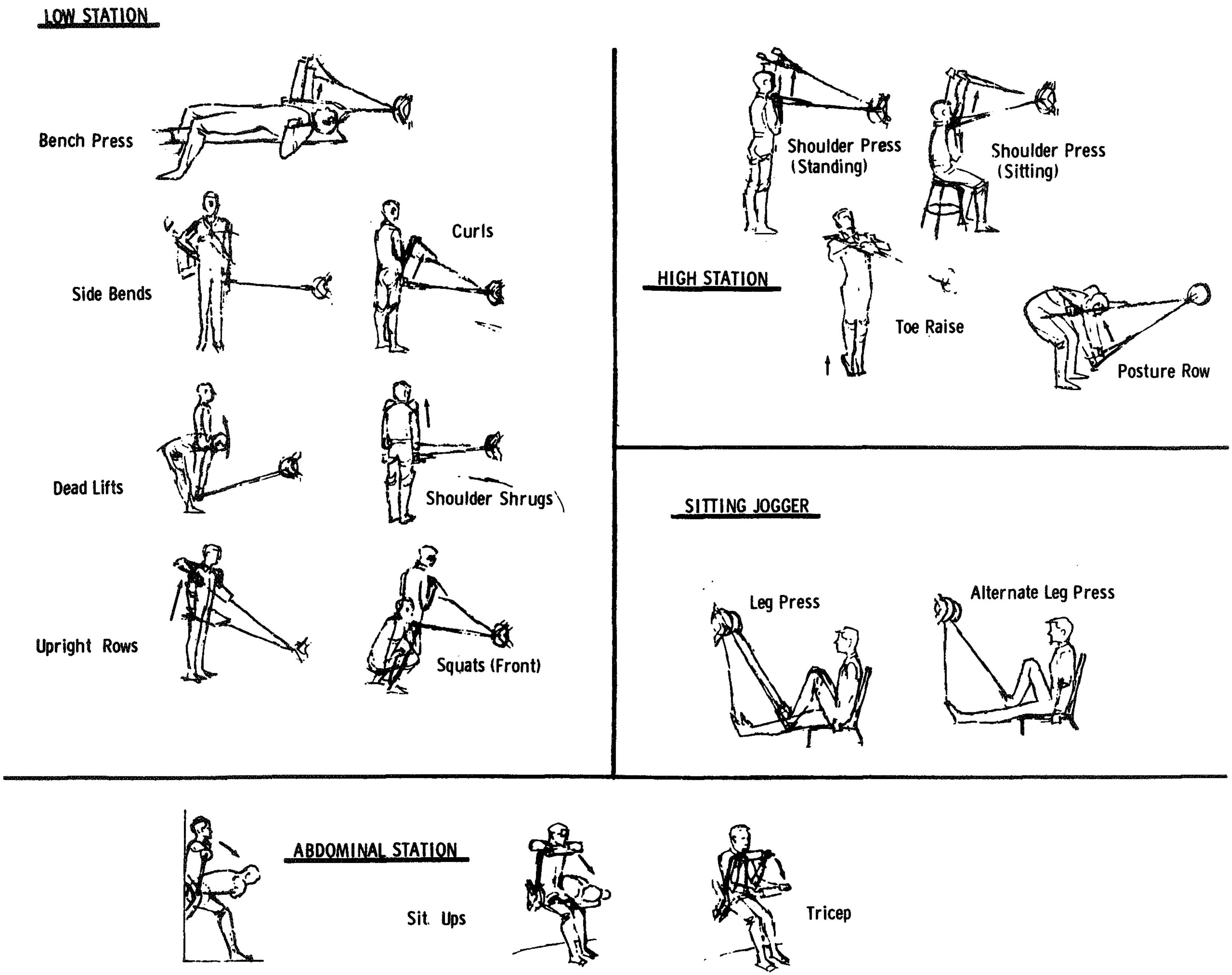


FIGURE 9. POSSIBLE EXERCISES IN PERIPHERAL HEART ACTION PROGRAM

Many professional and Olympic quality athletes have employed peripheral heart action training. Coker (Personal Communication, 1970), a past Olympic coach, states that peripheral heart action weight training can exceed the requirements for heart rate maintenance that Olree has developed. Additionally, this exercise program permits accomplishing all exercise objectives in twenty minutes per day on Earth.

Universal Athletic Sales Company has developed exercise equipment for a peripheral heart action training program which appears to be the best of present or near future equipments. It meets the first two functional specificiations and optimizes the third.

The unit utilizes a central resistive source with attachments to permit many different exercises. The central resistive source employed is similar to an automobile disc brake. This permits the amount of resistance to be easily adjusted over a wide range. The attachments currently being designed approach the stow and deploy requirements for the spacecraft. A recent development is the provision for vertical adjustment shown in Figure 10. This increases the acceptability of this unit by making it easier to adjust for different exercises.

In summary, there are several alternative approaches to exercise equipment. Our choice among these equipments cannot be considered authoritative because of inadequate information in two areas:

1) Biomedical requirements for exercise.

2) Quantitive comparison of means to meet these requirements.

These areas should receive further investigation. The second area, unfortunately, is not easily isolated for effective investigation--motivation is an important component.

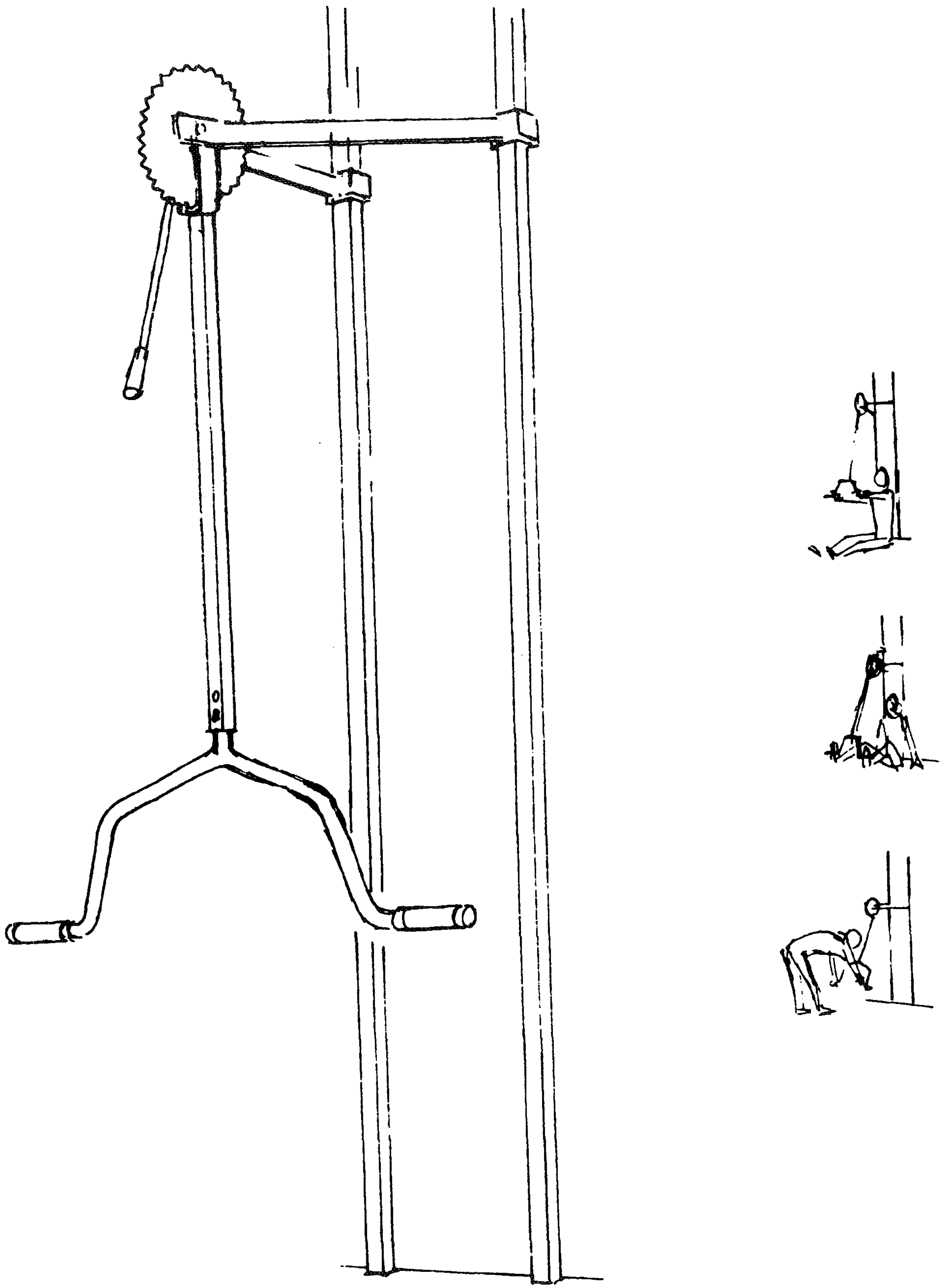


FIGURE 10. VERTICAL ADJUSTABLE RESISTIVE EXERCISE DEVICE

Motivation to Exercise

The low level of physical fitness in our society is reason enough to consider motivation to exercise as part of this study. The bio-medical criticality of exercise in zero or reduced gravity makes consideration of motivation mandatory.

Other than the astronauts themselves, candidates for inclusion in the space station and space base crews may well not meet the necessary fitness standards. According to Olree, to meet astronaut fitness standards, an individual needs to exercise properly twenty minutes per day, five days per week on Earth. From Table 20, the astronauts exercise more often now and intend to exercise more often in space than the other relatable groups. Indeed, two of the groups, the tactical fighter pilots and the aerospace engineers, do not expect to spend as much time exercising in reduced or zero gravity as the astronauts spend presently.

TABLE 20

MEANS OF EXERCISE FOR EACH GROUP TESTED

	Present	Spacecraft
Astronauts	3.37*	3.83*
ARPS Pilots	3.02**	3.64*
Tactical Fighter Pilots	2.81**	3.03**
Aerospace Engineers	2.59**	3.28**

* Indicates "up to daily use".
** Indicates "up to a few times a week".

Of those wintering over in Antarctica, the enlisted Naval personnel had the highest percentage of men who exercised with sufficient frequency to meet astronaut standards. However, there is no indication that the exercise was sufficiently strenuous to reach the level of fitness recommended for astronauts. The group most comparable to the astronauts, by preferences and level of education, is the civilians. Only 14 to 21% of the civilians exercised with a frequency equal to that necessary to reach astronaut standards (and again, it is questionable whether they exercised sufficiently strenuously - Table 21).

TABLE 21

PERCENTAGE OF PERSONNEL EXERCISING "EVERY DAY" OR "A FEW TIMES A WEEK" IN ANTARCTICA*

	Early	Late
Enlisted Navy	41%	31%
Civilians	14%	21%

*Doll and Gunderson, 1969.

Quantitative measurement of exercise performance is necessary for all of the motivational methods we shall discuss below. The effort of the subject may be measured in either physical or physiological parameters. The physical parameters are force, time, distance, work accomplished, and rate of accomplishment of work. Applicable physiological parameters are those measuring output of heart, lungs, and muscles such as heart rate, breathing rate, electrical muscle potential, and many others. Additionally, these two types of parameters may be combined in various ways to yield other measures of performance.

The biomedical standards for exercise programs can be translated into one or more of the above measures. In selecting the measure(s), however, it should be noted that all possible measures are not necessarily equivalent for motivational purposes. Motivation should be considered in selecting the measure or measures of performance.

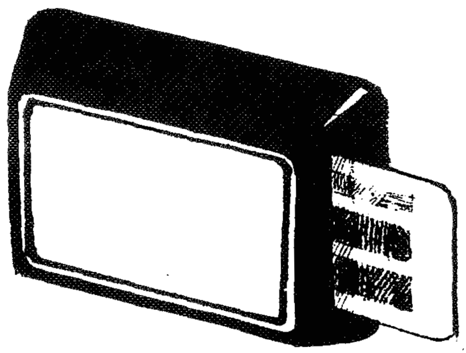
One of the foremost ways of building satisfaction with the exercise program is to supply feedback on performance. When a person knows that he is approaching and reaching properly set goals, he is motivated to continue the program. To be effective, however, the standards, goals, and feedback methods must be appropriately selected.

The characteristics of the display of the standards and feedback will have an effect on motivation to exercise. Orientation, color, indication of standards, and other characteristics of the information display device are all important. For greatest flexibility, a television screen is suggested as a display (Figure 11).

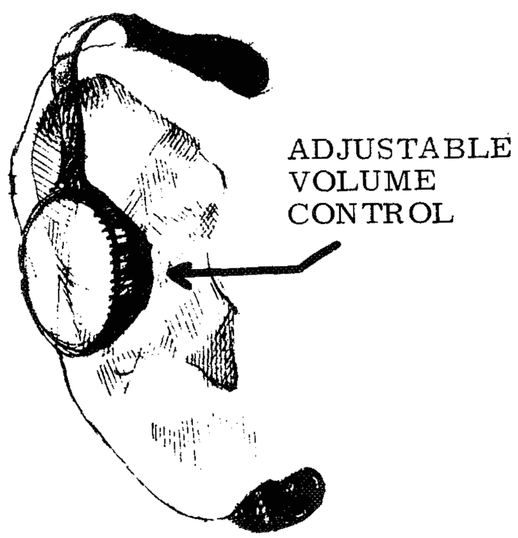
Individualized standards for each crewman could be entered and then displayed on the television screen with coded card. The card could be updated by the biomedical personnel at regular intervals to correct for inappropriate standards previously set. This technique would provide an updated exercise program related to an individual crewman's requirements and capabilities.

The possibility of controlling the display on the television screen through exercising suggests a motivational opportunity. Performance in the exercise program could be related to a psychomotor performance task displayed on the television screen. The display itself would be easy to change, and possibilities for the display are unlimited.

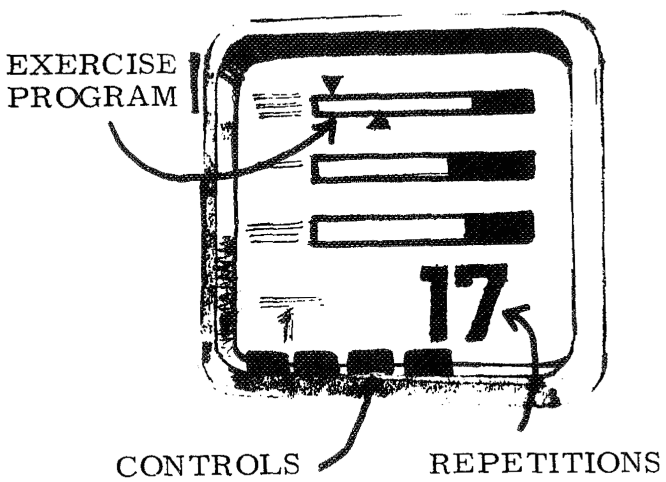
Positive incentives as motivational tools to increase the effort expended in exercise per unit time should be investigated. Two approaches



EXERCISE PROGRAMMER



HEART RATE SENSOR (IN EAR) FOR
MONITORING AND FEEDBACK



PERFORMANCE FEEDBACK DEVICE

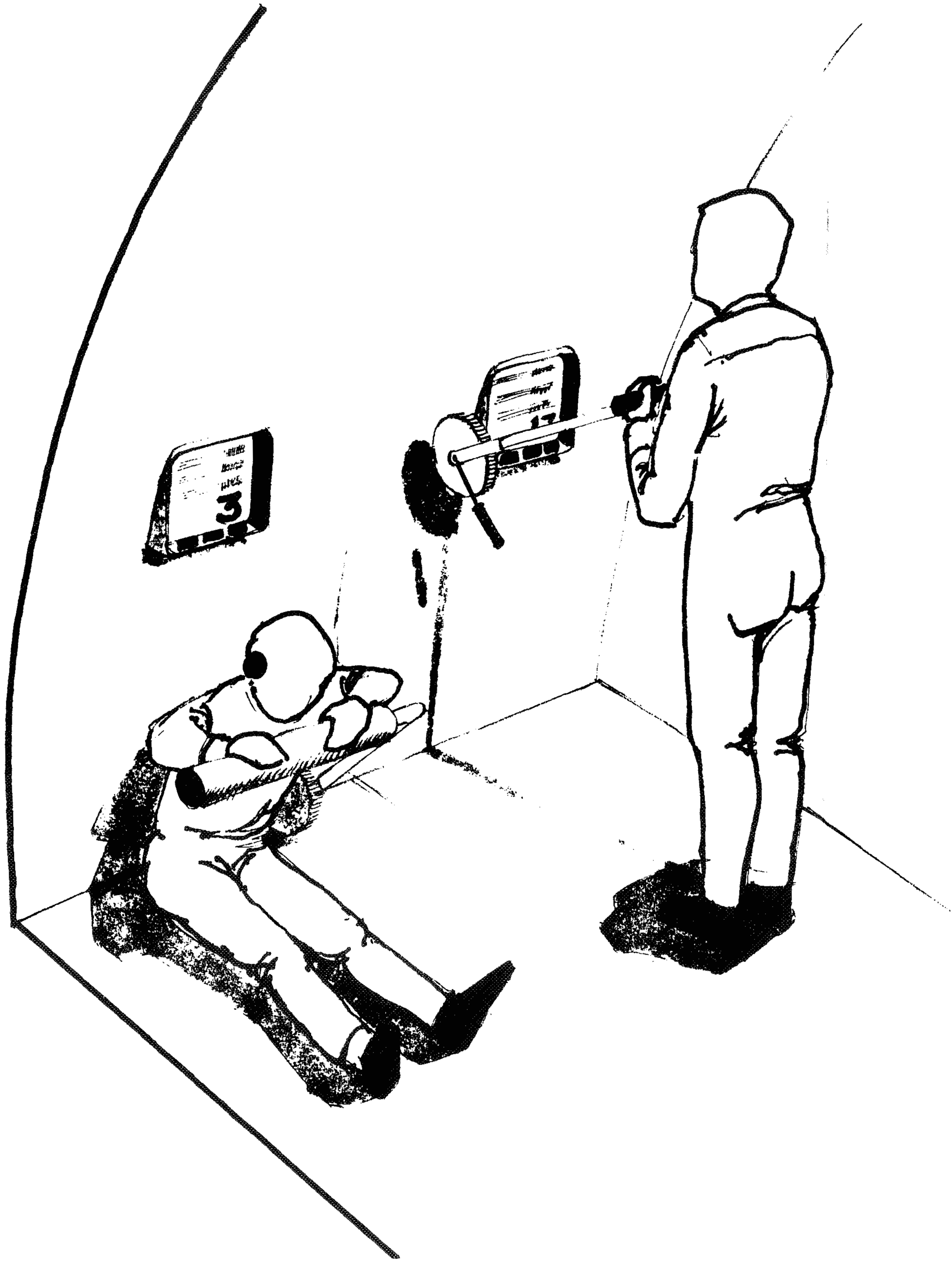


FIGURE 11. TECHNIQUES TO ENHANCE PERFORMANCE OF EXERCISE

are suggested. The first is reward of high expenditure of effort in exercise with reduced exercise time. This is feasible only if the biomedical requirements may be stated in a manner which is not completely time dependent. The progress towards a reduction in time could be one of the items displayed on the television screen mentioned before.

The second positive incentive to expend more effort on exercise is competition. Although indications from the literature on confinement are that competition is likely to have a negative impact on morale, there may be ways of eliminating this effect. Evaluating fitness in various parameters may reduce the negative aspects of competition. Handicap methods are the most widely used attempts at this.

OTHER

This section discusses the equipment necessary to support leisure activities within the space station/base. Leisure furniture, lighting, interior decoration, noise and sight isolation, telescope and porthole, and provisions for privacy are included (Figure 12).

Chairs and tables must be provided for both zero and reduced gravity. They should be designed so that they can be used for a variety of purposes. The chairs should be movable so that they can be located in different places around the compartment. Thus, games, lounging, snacks, and talking could all be accommodated at different times. Both tables and chairs should be collapsible so that they can be stowed out of the way when not in use. To eliminate the necessity for compartment doors to contain stowed tables and chairs, one surface of the table or chair might serve as the door of the compartment.

It is expected that frequently there will be many different activities occurring in the space station off-duty facility simultaneously. Some activities will be distracting to persons undertaking different activities.

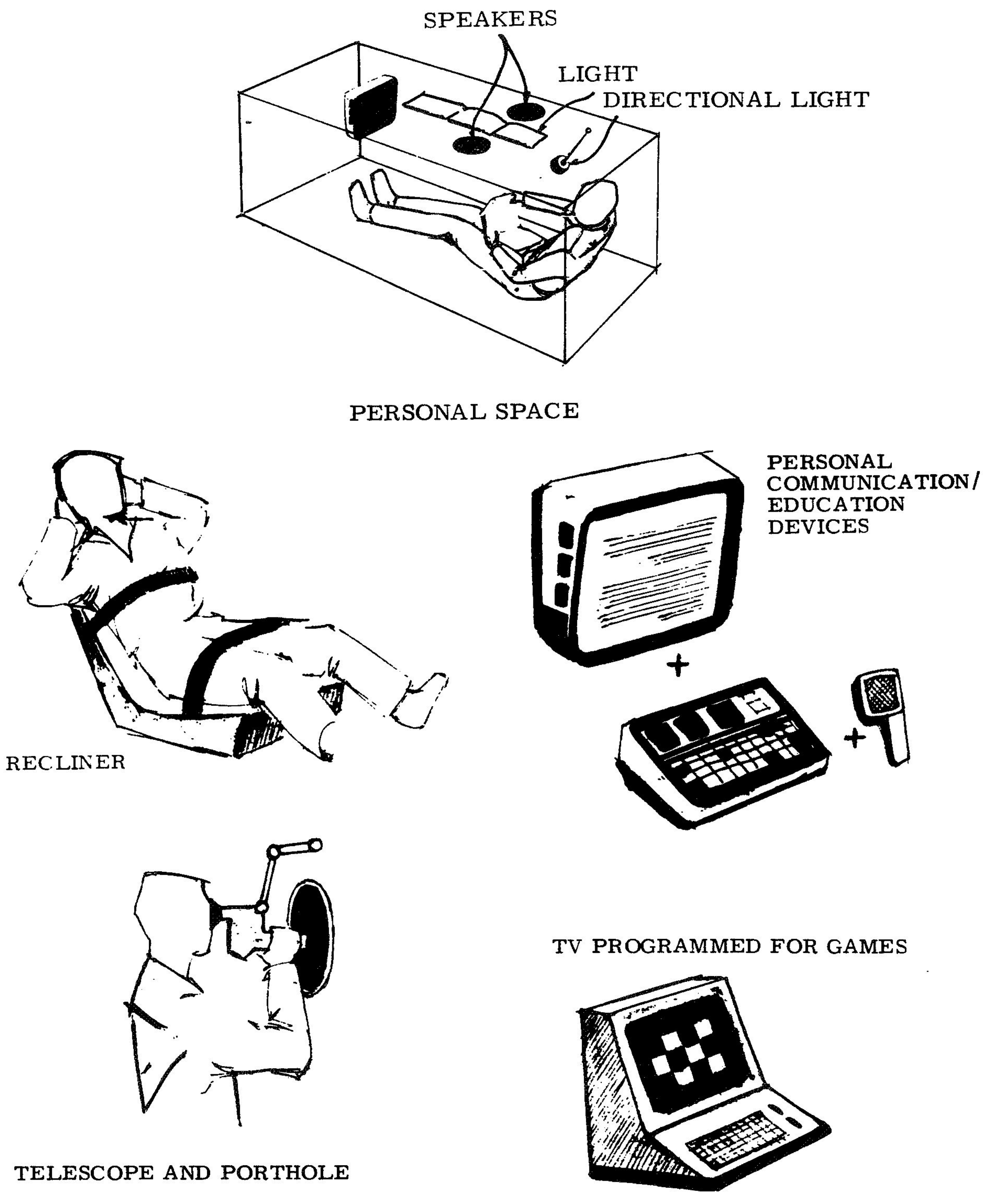


FIGURE 12. LEISURE EQUIPMENT

To prevent conflicts between individuals engaging in different activities, some means must be available for insulating personnel from each other. Ideally, both sight and sound insulation should be available.

Sight insulation can be provided through the use of opaque materials. One method of deployment of the opaque materials is to attach a thin fabric to the movable nets provided for sports. Sight insulation could be provided in this way with minimal additional equipment.

Sound insulation can be provided through the proper design and use of the sound output equipment. Control of volume levels and proper use of headsets are the key. A rule that the "sound rights" go with the activity that has most people involved would provide a solution to the proper use of headsets; the minority will use them.

All surfaces in the leisure area should be padded to prevent injuries. It is suggested that padding be achieved where possible with reversible and/or interchangeable colored panels. This will provide opportunities for redecoration. The color scheme of the off-duty facilities should be selected to provide an illusion of greater size. The possibility of achieving an illusion of depth should be investigated.

The general lighting should be recessed behind protective panels. This, we expect, will be the solution in all parts of the space station and space base.

The equipment required to support the off-duty activities include:

Activity	Selected Equipment
Watching TV shows	Television set, tape cartridges, cartridge players.
Watching movies (space base only)	Movie projector, movie film.

Activity	Selected Equipment
Reading books	Hard copies, microfilm, microfilm reader.
Reading magazines	Tape cartridge, cartridge player, microfilm production equipment, microfilm reader, character generator, TV set, automatic typewriter.
Listening to music	Tape cartridge, cartridge player, group and individual speakers, headsets.
Games	Darts, target equipment, chess, checkers, scrabble, cards, individually chosen hobby equipment.
Sports	Spring return nets, sports inventor's kit, balls, rackets, etc.
Exercise	Resistive exercise equipment, performance improvement equipment.
General leisure	Chairs, tables, personal chambers, screens for noise, writing materials, communication to Earth, viewports in space station, photographic equipment.

CHAPTER V

RECREATION FACILITY DESIGN AND LAYOUTS

This chapter presents factors which were considered in the design of the recreational facilities and some recreational facility layouts for the space station and space base. Two objectives guided these efforts; namely,

1) Development of layouts permitting the greatest variety of preferred activities.

2) Development of layouts which would permit simultaneous participation in as many different activities as possible without interference between the activities.

Before turning to the layouts themselves, two preliminary considerations require further discussion. These are the designation of the "floors" in the facilities and the basis for usage of the two separate rooms which are available for the space base recreation facility.

PRELIMINARY CONSIDERATIONS

Designation of "Floor"

Figure 13 relates the dimensions of the space station and each space base recreational facility to human dimensions. The man in Figure 13 represents the 99th percentile crew member. Such a crew member is six feet tall. As shown at left in Figure 13, if the floor is taken as one of the two semicircular surfaces, the resulting 78 inch ceiling height will clearly limit the overhead arm movements of the six foot man. This limitation occurs in both the space station and the space base since the 78 inch dimension is common to both. On the other hand, if the floor is taken as the flat inner wall as shown on the right in

Figure 13, crewmen will be able to raise their arms above their heads. If this wall is designated floor in the space station, the available floor area becomes 117 square feet (not including the area occupied by the airlock) as compared to 184 square feet when one of the semicircular surfaces is designated the floor. Using the inner wall as the floor is a permissible orientation in the zero gravity space station; however, it is not permissible in the space base because the 0.3 g gravitational field is expected to be perpendicular to one of the flat semicircular surfaces.

Although the inclusion of a gravitational field in the space base was originally considered advantageous, it is now questioned. In the space station, because there is no necessary floor, the floor may be reoriented as required to best suit the activities to be undertaken. In the space base facilities, however, we were forced to use the defined floor created by the gravitation field as the point of departure for recreational facility layout. This severely limited the alternatives during the design process.

Usage of the Two Rooms Available in the Space Base

As will be remembered, two rooms of equal dimensions will be available for the space base recreational facility. The rooms will be on separate levels and cannot be combined. Before developing layouts for the space base recreational facilities, it is necessary to consider the usage of these two rooms.

As has been mentioned, the crew members aboard the space base will include both technical support and professional personnel. Also as has been shown, there are off-duty activities preference differences which tend to correlate with these two groups. Since there are two facilities, one possibility is to design a recreation facility for professional personnel and a recreation facility for technical support personnel. An alternate possibility is to design the facilities for different functions;

SPACE STATION
Zero Gravity
Crew -- 6 to 12
Area -- 184 Square Feet;
Per Crewman
-- 30.6 to 15.3 Square Feet

SPACE BASE
0.3 Gravity
Crew -- 50 to 100
Area -- 842 Square Feet;
Per Crewman
-- 16.8 - 8.4 Square Feet

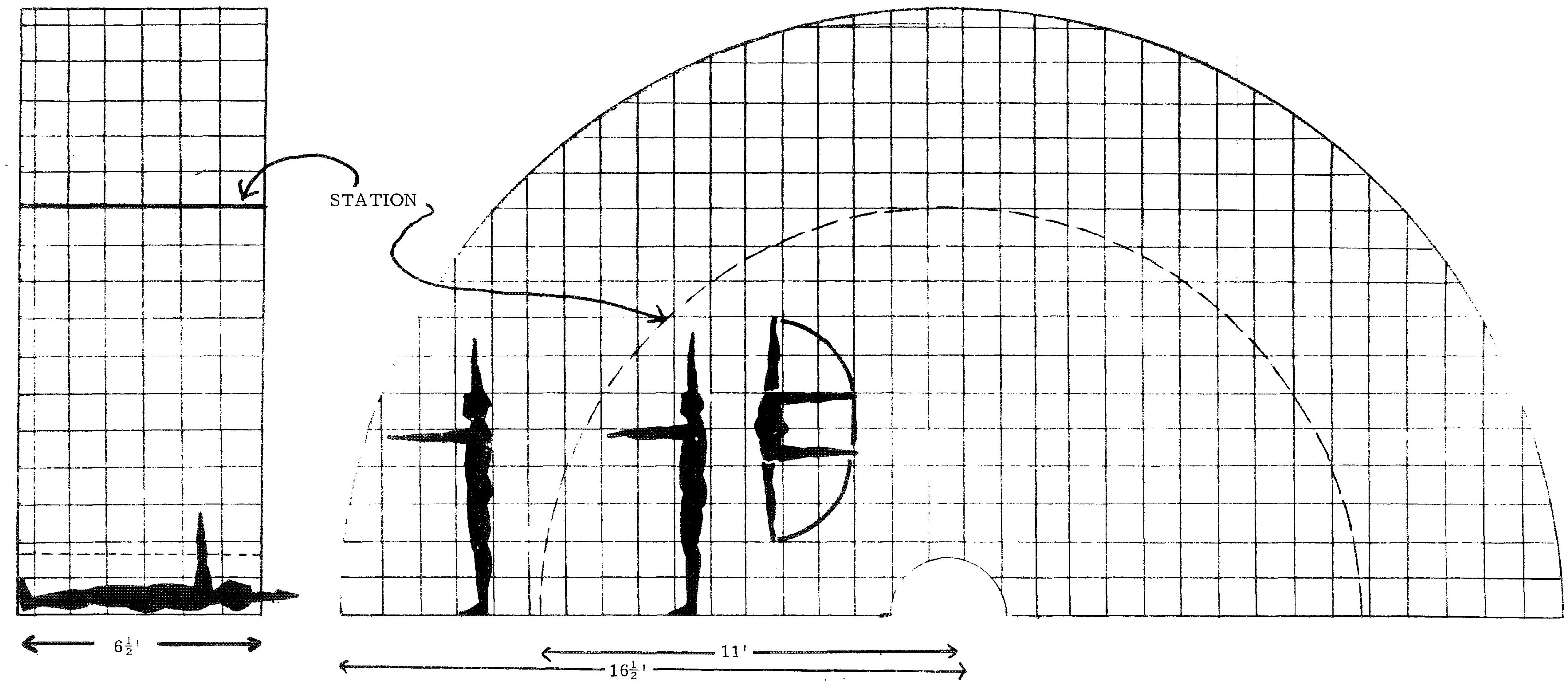


FIGURE 13. SPACE STATION/BASE RECREATION FACILITY VOLUMES RELATED TO HUMAN DIMENSIONS

for example, a leisure activities facility and an exercise/sports facility.

We have selected the second approach. We feel it is important to separate exercise and sports from such general leisure activities as reading, studying, writing, talking, watching TV and movies, etc. We are unsure whether separating technical support and professional personnel for recreational purposes is a good idea or a poor one. Arguments could be advanced for either position.

SPACE STATION FACILITY DESIGN

A three-step approach was followed in the design and development of layouts for the space station recreational facility. The three steps were:

1) Selection of the surface which will be used as the floor for the various types of activities;

2) Consideration of types of construction materials and facility configurations; and

3) Development of the facility design recommendations.

Floor Considerations

The first step in integrating the various activity requirements into the space station was to determine where the floor should be for the various activities. Figure 14 shows two floor possibilities when the facility is used for exercise. If the $6\frac{1}{2}$ foot dimension is used for the floor to ceiling distance (Figure 13), a six foot crew member clearly cannot extend his arm over his head. However, if the floor is the inner central wall of the facility, overhead arm extension is

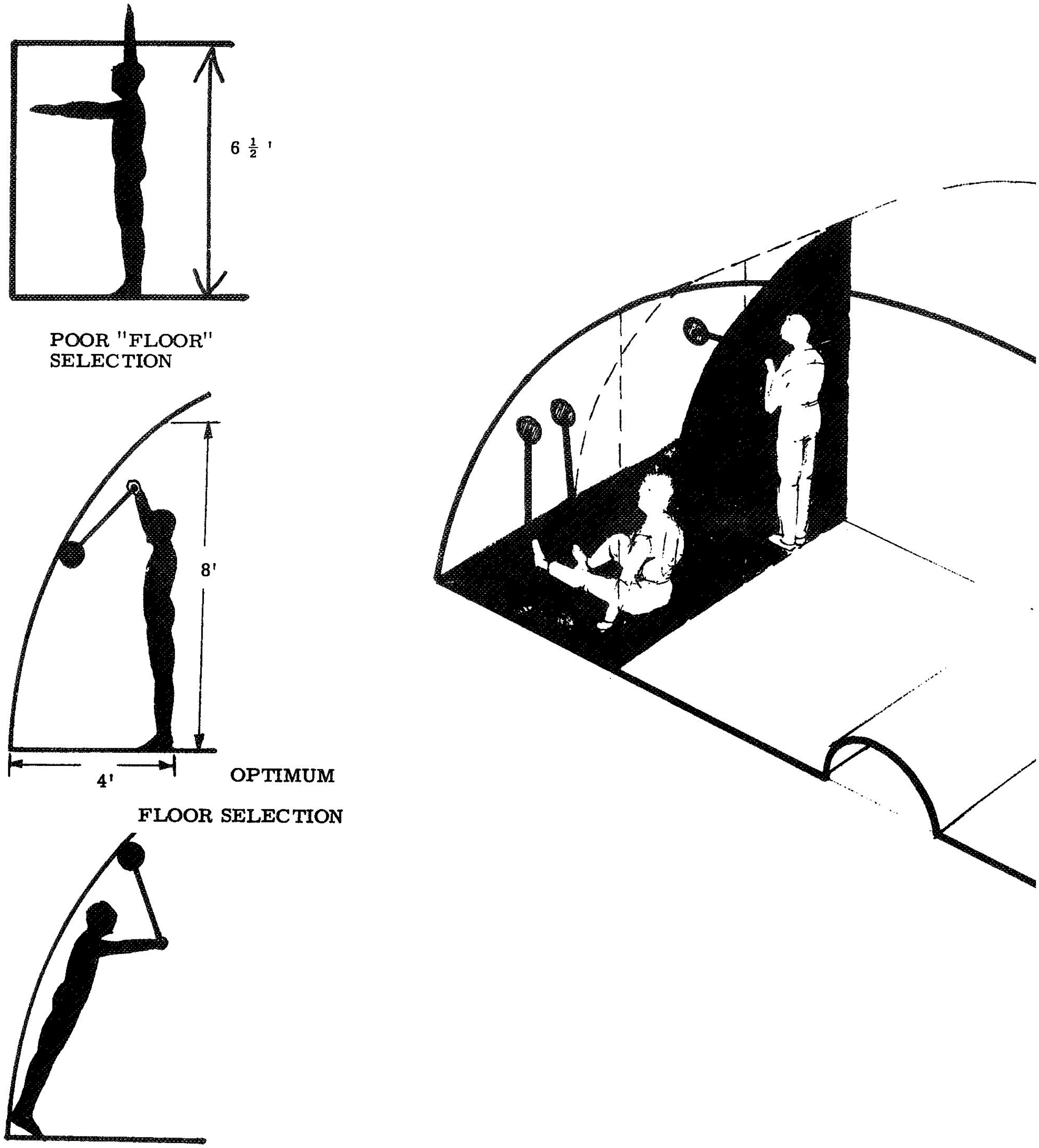


FIGURE 14. SELECTION OF FLOOR SPACE FOR
VARIABLE RESISTIVE EXERCISE DEVICE

possible and crew members could readily use the resistive exercise device previously recommended (Chapter IV) in all necessary exercise configurations. Therefore, the recommended floor, when the facility is used for exercise, is the inside rectangular wall of the room.

For activities other than exercise, designation of the floor is less important. For sports, it is advantageous to consider all of the surfaces "potential floors", depending upon the floor assignment which best suits a given sport. Indeed, crew members may wish to vary which surface is selected as floor to add variety to their environment.

Optimal integration of the personal chamber or chambers which permit individuals to be alone in the station requires consideration not only of the floor but also of the chambers themselves. Various possibilities are illustrated in Figure 15. Self-contained, movable, cylindrical personal chambers are an inefficient use of volume, especially if against a wall (see black areas). Since the personal chambers are used for passive activities, a $6\frac{1}{2}$ foot height for these chambers is adequate. In the zero gravity environment, designation of the floor for the personal chambers in relation to the room is unimportant and a number of orientations of personal chambers are possible (Figure 15).

Materials Considerations and Some Facility Configurations

Two basic concepts for the surfaces of the overall facility and for the equipment within it (tables, chairs, etc.) were considered. These were hard and soft (inflatable). The "hard shell concept" of design indicates a facility, associated structures (wall coverings, room dividers, etc.), and equipment all formed of noninflatable materials. The "soft shell concept" of design is a facility, associated structures and equipments formed of inflatable materials. These two concepts and their combination are illustrated by using them in the design of several facility layouts.

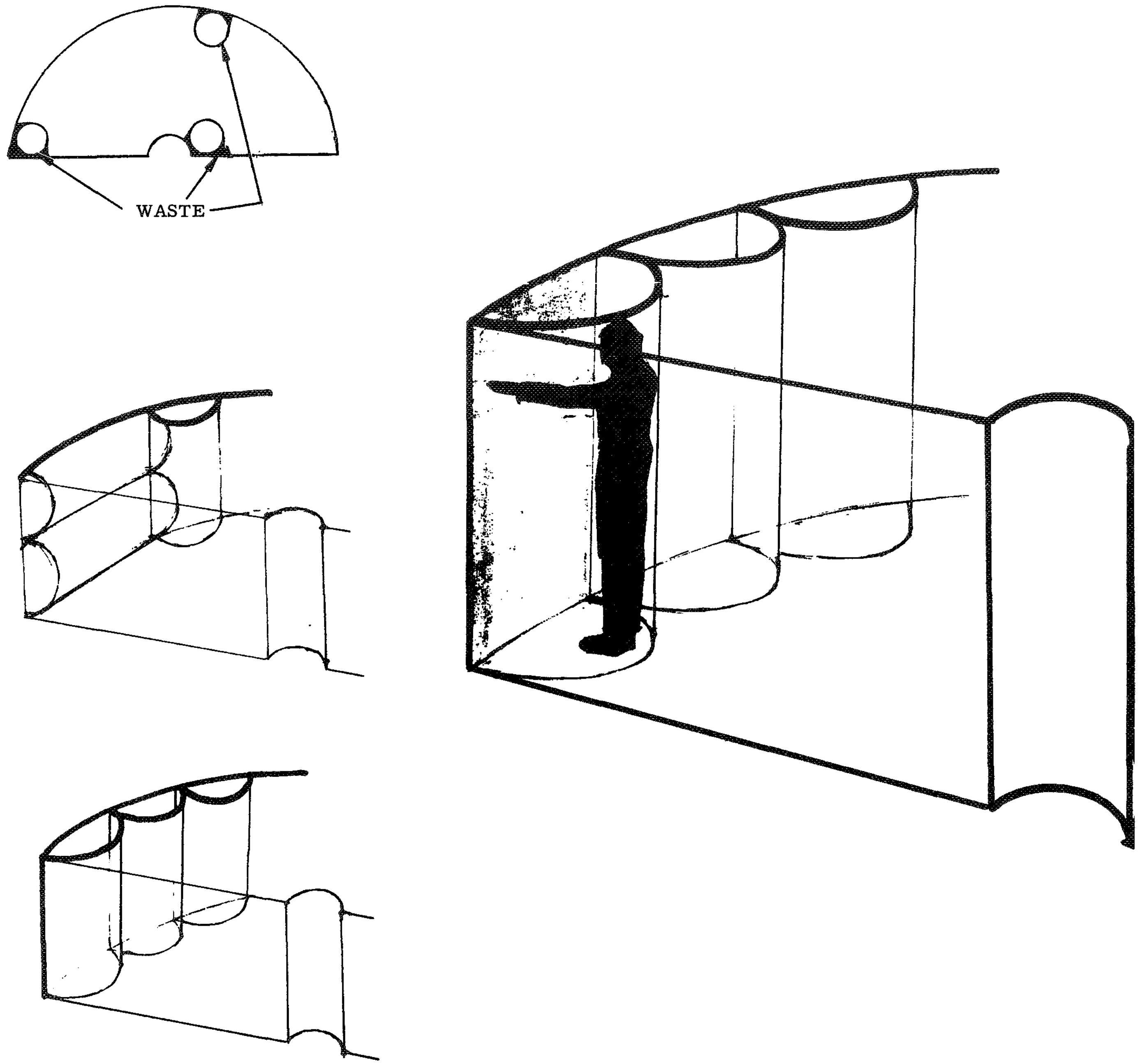


FIGURE 15. INTEGRATION OF PERSONAL SPACE
INTO SPACE STATION RECREATION FACILITY

The hard shell concept is shown in Figure 16. The curved portion of the facility is used for storage, lighting and to provide equipment such as furniture. The inserts provide further detail.

As shown in the top left insert, the stowed cross section of the wall is approximately six inches deep. The middle insert shows the deployment of a hard shell personal space. The bottom insert shows a game area containing a hard shell table and hard shell chairs.

The main part of Figure 16 shows one of the alternate configurations into which the facility can be deployed. The crewman at left is exercising, the two crewmen in the center are participating in a sport, the equivalent of handball, and the two crewmen at right are playing a board game. A personal space compartment is shown at the upper left in the main drawing. Notice that the personal space limits the man who is exercising to exercises which do not require him to lift his hands above his head unless seated. Only the central and low resistive exercise stations (Chapter IV) could be used.

Also shown in Figure 16 are the nets which have been recommended as boundaries of sports activities (Chapter IV). In the actual facility, additional boundary material is recommended to reduce sounds and permit better ventilation of the sports area, thus providing a better environment for nearby games and leisure activities (see right side of figure). At the very minimum, the light fabric suggested in Chapter IV to cover the nets is recommended.

The soft shell concept is shown in Figure 17 with alternate deployments on the left hand side. At top left, personal spaces have been combined into a semiprivate conversation area for three crewmen. At left center, a table and four chairs have been deployed from inflatables which are stowed in the wall sections when not in use. Collapsed, these inflatables would easily fit into six inch storage sections. In the lower insert, six benches are shown deployed and arranged for conversation. As shown in the insert, the bases of the inflatable benches can be attached to a surface (black rectangles).

Figure 18 shows a combination of hard and soft shell concepts. The inserts provide detail on alternate deployments. Note in the main figure that the feet of the man exercising are fastened to a base. The two people in the center are playing the equivalent of handball. At right, four people are participating in two different activities. Finally, there is a man in the personal chamber shown at upper right. The configuration uses a combination of hard shell main walls and soft shell dividers. The soft shell dividers are shown forming a personal space, in combination with hard shell panels deployed from the main wall. The tables and chairs in the insert labelled "Games" have hard shell tops and inflatable bases as is also true of the chairs in the insert labelled "Conversation".

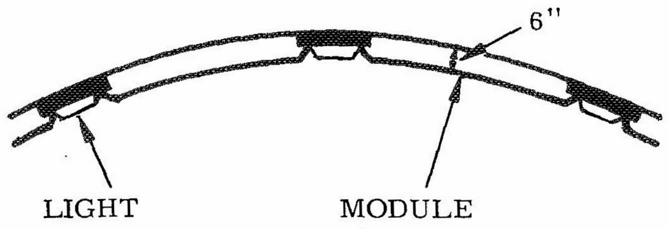
Design Recommendations for Space Station Facility Layout

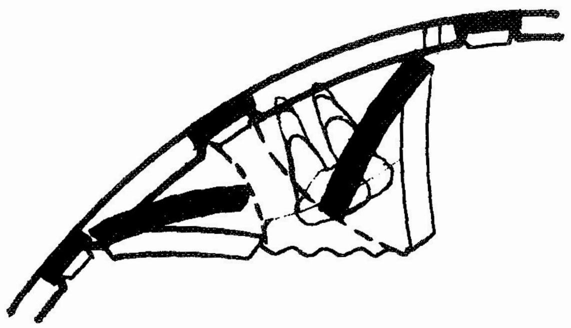
Because of the obvious increase in design flexibility, use of both hard shell and soft shell concepts is recommended. The combination should use rigid materials where necessary (such as chair seats and table tops) and inflatable materials wherever possible. A large proportion of inflatable pieces facilitates stowage and the soft surfaces characteristic of these pieces will reduce the occurrence of injuries when the facility is in use.

Other characteristics of the recommended facility in the space station are:

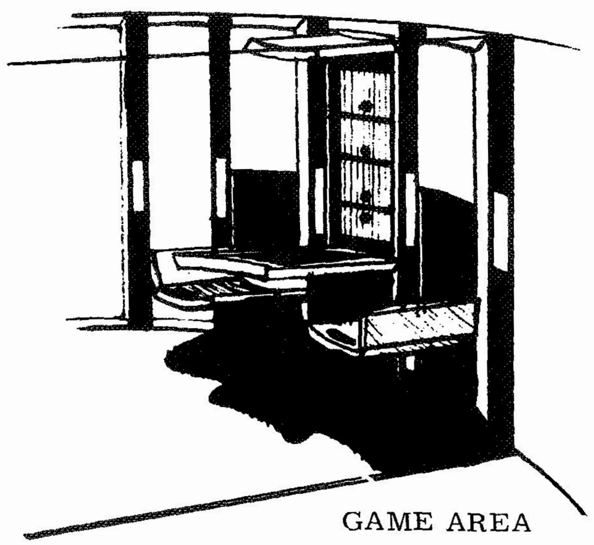
1) The facility is flexible. This is the keystone to effective design. The facility must be deployable in a variety of ways to support different activities.

WALL CROSS SECTION





DEPLOYMENT OF PERSONAL SPACE



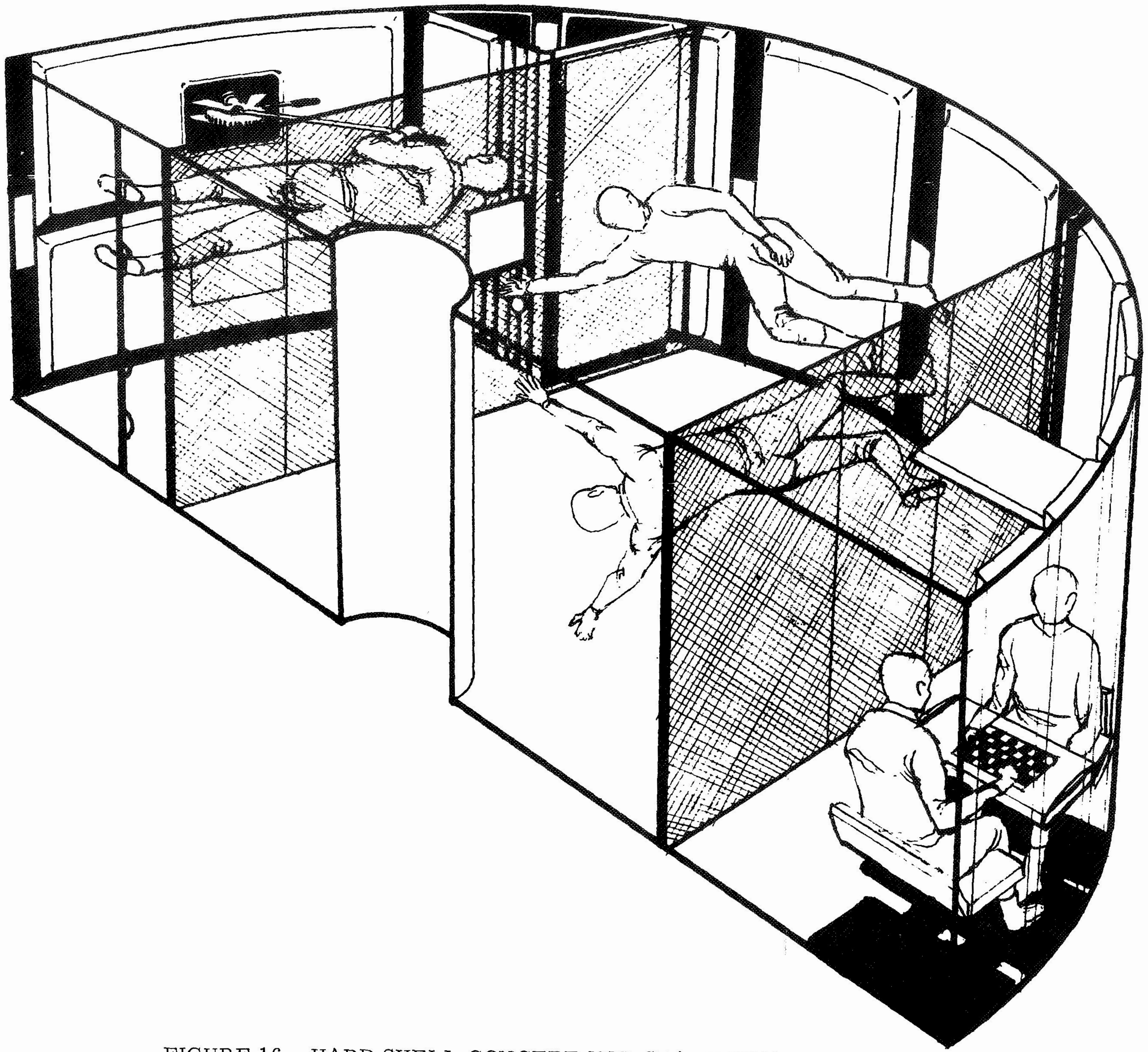
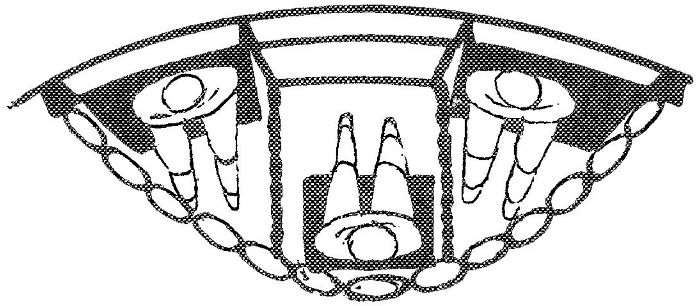
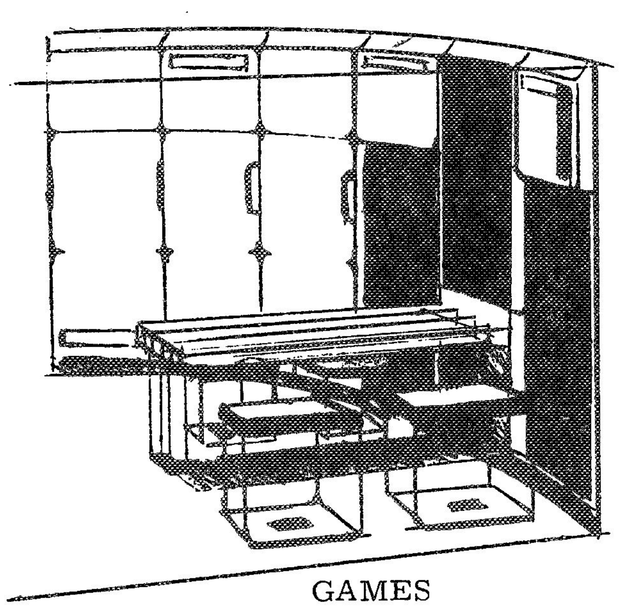


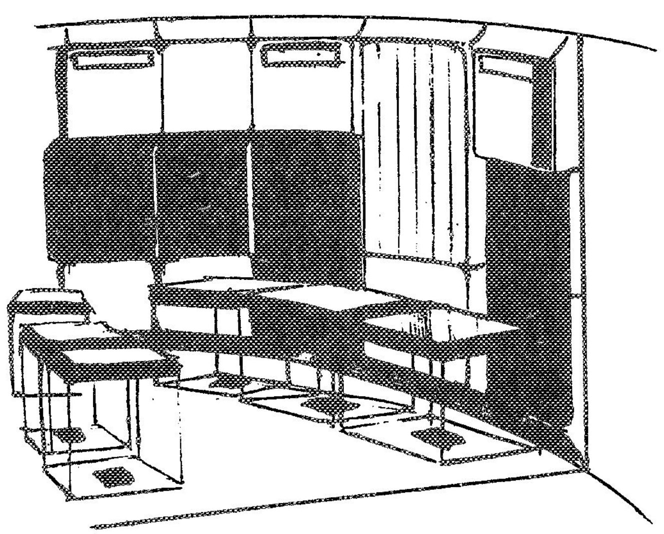
FIGURE 16. HARD SHELL CONCEPT FOR SPACE STATION



TOP VIEW - PERSONAL SPACE COMBINED FOR CONVERSATION



GAMES



CONVERSATION

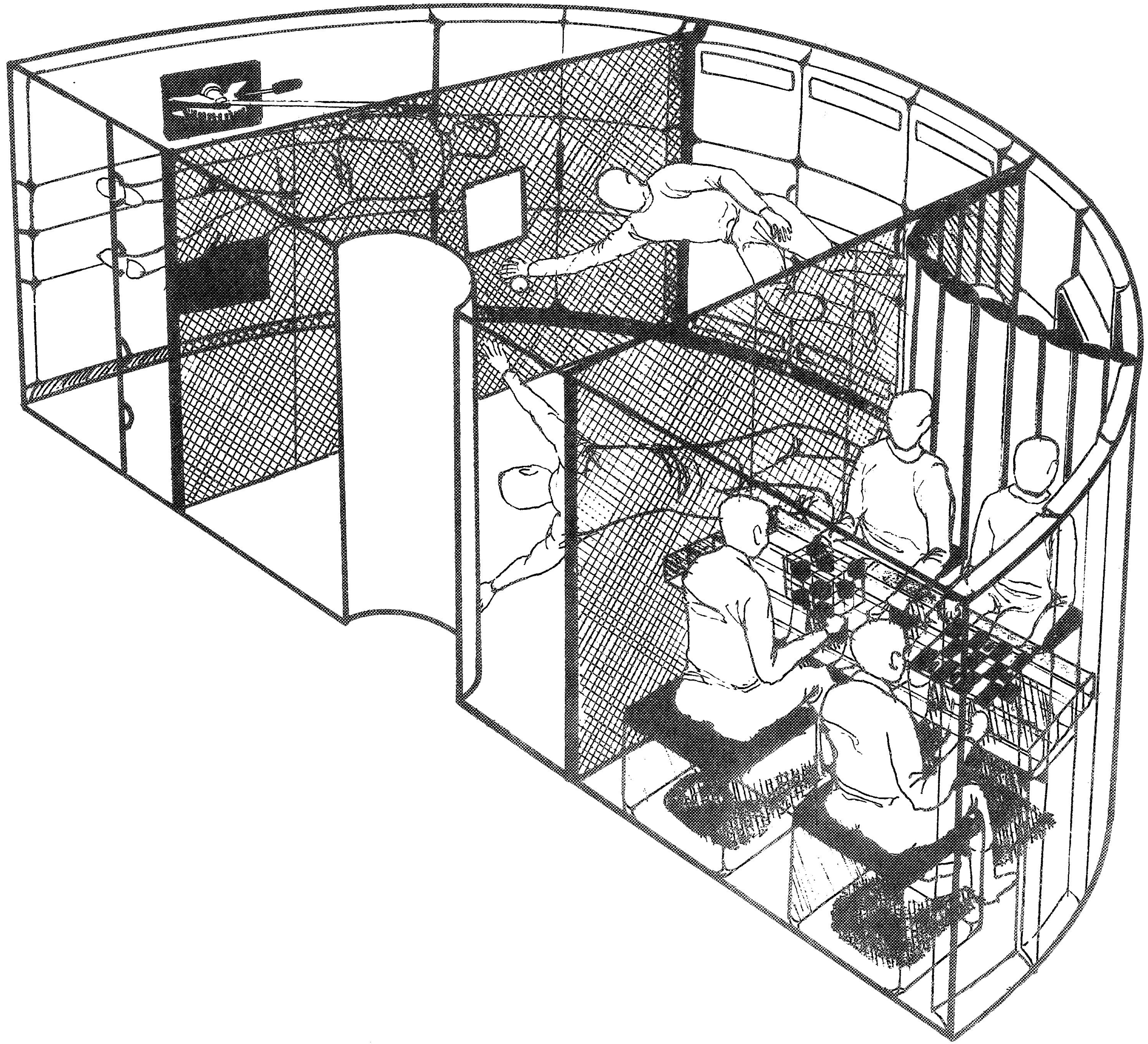
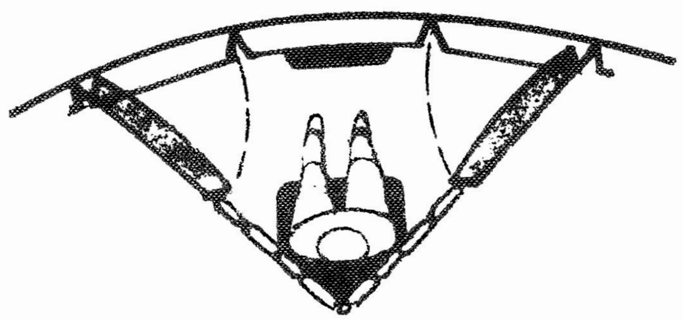
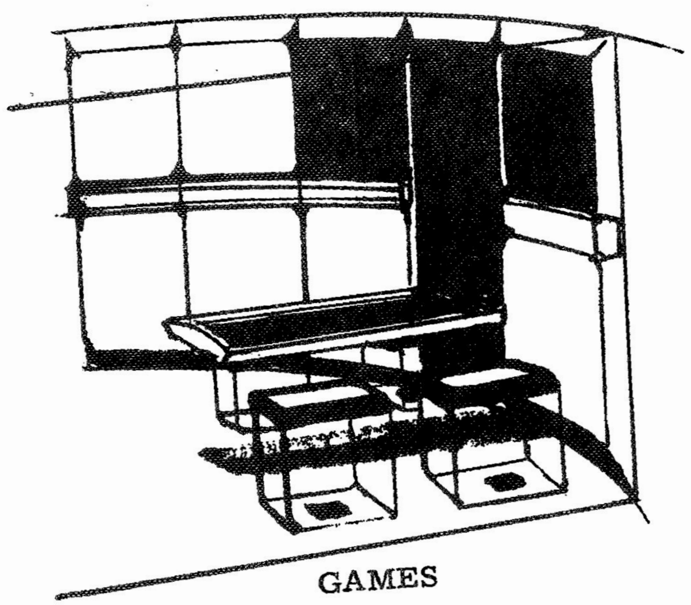


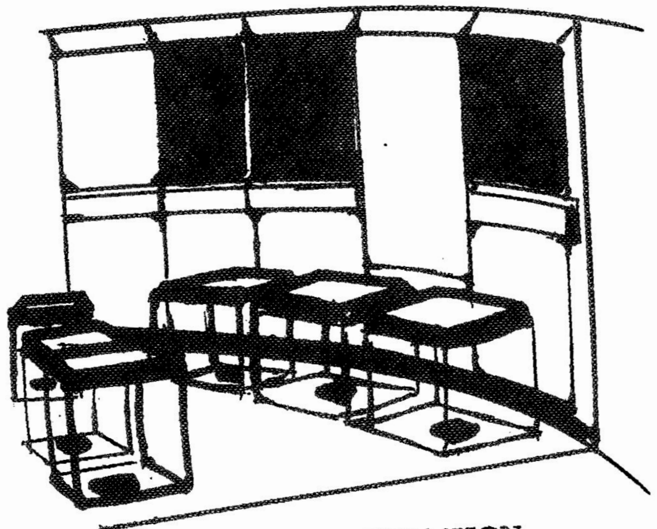
FIGURE 17. SOFT SHELL CONCEPT



PERSONAL SPACE



GAMES



CONVERSATION

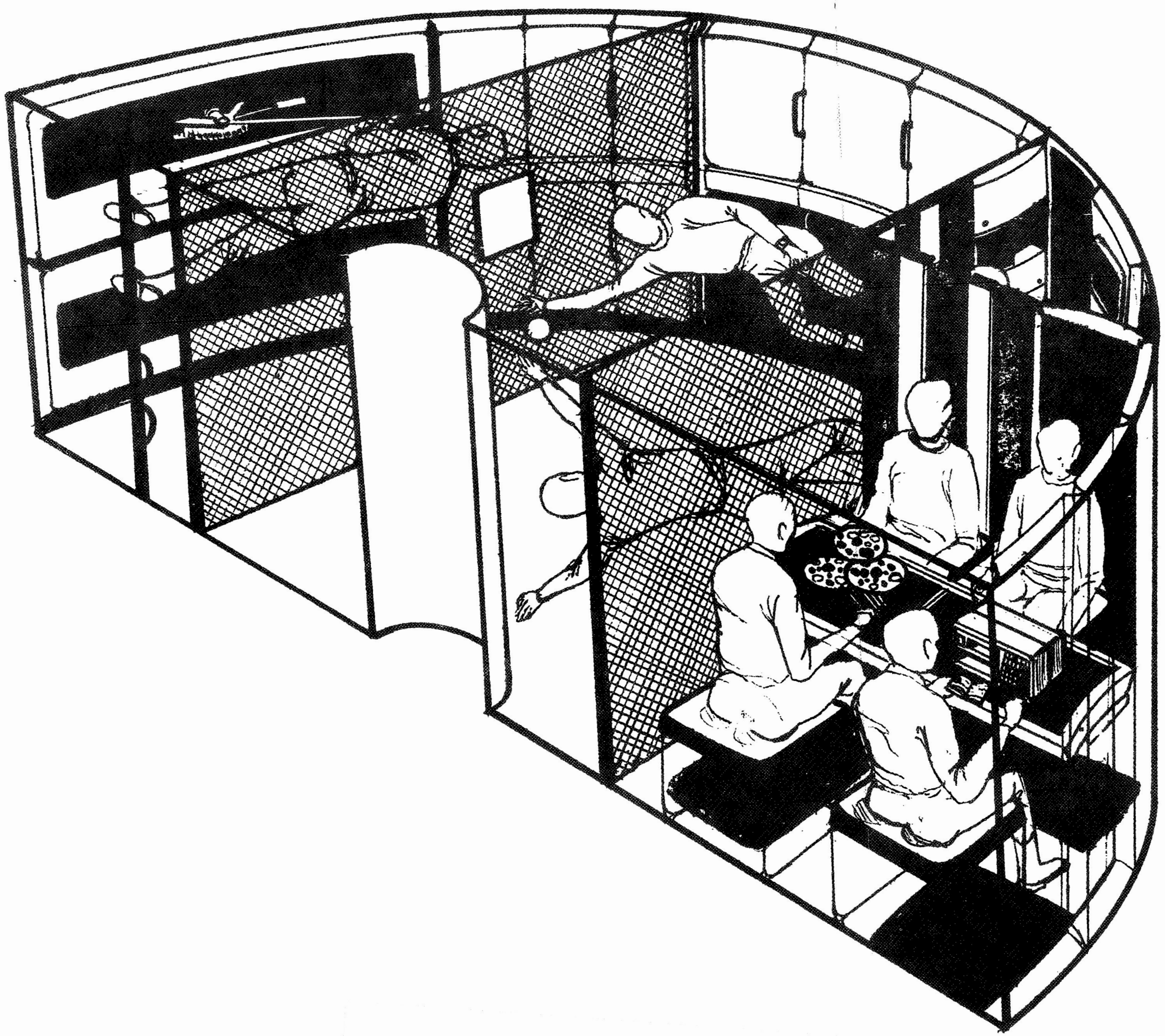


FIGURE 18. COMBINATION OF HARD AND SOFT SHELL CONCEPT

2) The surface of the facility selected as the floor varies as required to best support the particular activity or combination of activities for which the facility is to be used.

3) The facility structural materials (room dividers, etc.) and equipments (chairs, tables, etc.) are stowable.

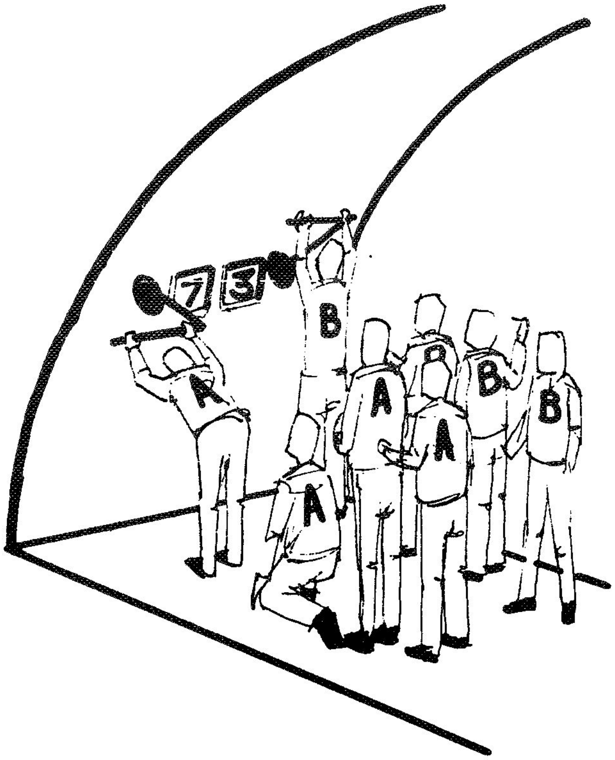
4) All preferred activities can be performed in the facility.

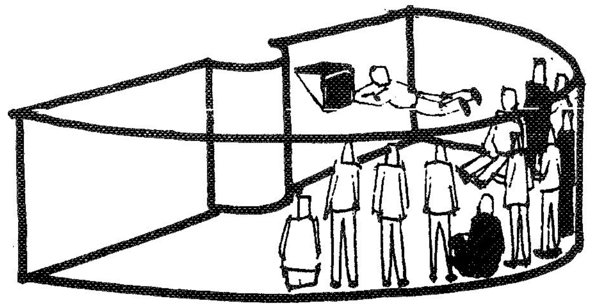
5) The facility can contain the entire twelve man crew. In this case, the crew members may all participate in one activity or may engage in several activities simultaneously. However, when the entire twelve man crew uses the facility simultaneously, it is recommended that if sports or exercise is to be undertaken, these be performed as group activity. Attempts to combine either of these with other activities with the full crew in the facility is not desirable (this is discussed further below).

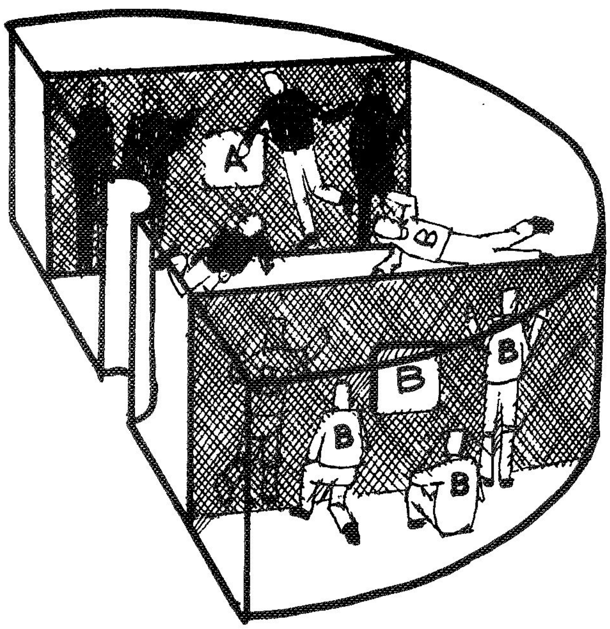
Two figures have been prepared to illustrate these characteristics further. Since simultaneous use by the full crew represents maximum load on the facility, twelve crew members are shown in these drawings.

Figure 19 is divided into four parts. At the lower right, the preferred activities which can be accommodated by the facility are listed. The remaining three parts of this figure show the facility deployed to support three different activities, in each of which the entire crew is participating.

At the upper left, the facility is in use for group exercise. The drawing shows the crew broken into teams. Team members could compete either as entire teams or on a paired basis. The drawing shows only two exercise stations. It will be remembered that if peripheral







POSSIBLE OFF-DUTY ACTIVITIES

Watching TV shows
Listening to music
Bull sessions
Reading
Doing nothing
Physical exercise
Eating snacks
Studying
Job-related activities
Personal communication
Playing sports
Being alone
Playing cards
Playing chess/checkers
Writing
Repairing something
Religious activites
Playing musical instruments
Photography
Playing board games.

FIGURE 19. SOME ACTIVITY POSSIBILITIES IN SPACE STATION

heart action training is used for exercise, a twenty minute exercise period is required on Earth. The exercise must be performed in one continuous period. If twenty minutes is adequate in space (and probably it will not be), then to exercise the entire crew with two stations will require two hours. The maximum number of stations that can be accommodated in the facility is probably six. This would mean that during the total exercise period for the entire crew, each crew member would spend half the time exercising and half the time watching. Depending on the time required for exercise, crew members not exercising may or may not wish to remain. However, a competitive team approach (with the possible use of handicaps to reduce potential morale problems) might make both the exercise and the period of nonexercise more interesting.

The lower left drawing shows the facility used for group sports. The nets for bounding the sports area are deployed to their most extreme position. In the resulting space, four and possibly six crew members could participate in a sport similar to handball. Again, the drawing shows the crew members divided into teams. The team members not playing are shown awaiting their turn to play outside the nets, possibly encouraging their fellow members who are playing.

With reference to use of the facility for group sports and group exercise, one comment is required. It might be suggested that the facility be divided, leaving some space for leisure activities while the remaining space is used for sports or exercise. However, this is probably not feasible if the facility is to be used simultaneously by a full twelve man crew. The reasons are: 1) lack of space; 2) difficulty of providing adequate ventilation; and 3) difficulty of insulating against sound. Therefore, when the full crew is to use the facility simultaneously, it is recommended that sports or exercise not be combined with other activities.

A third group use of the facility is shown at the top right of Figure 19. The entire crew is watching a sports event.

In the different group uses of the facility portrayed in Figure 19, it should be noted that the surface which might be considered "floor" varies with the activity. Also, all equipment, etc., not specifically required for each activity has been stowed.

Use of the facility by the entire crew for simultaneous participation in different activities is illustrated in Figure 20. The figure shows: 1) Two men using personal chambers; 2) three men involved in general conversation; 3) three men watching television (one of these is adjusting the set); and 4) four men, two of whom are playing a game and two of whom are using individual instructional devices.

This figure illustrates the feasibility of containing the entire twelve man crew in the space alloted for the recreation facility while still allowing diversity of activities.

SPACE BASE FACILITY DESIGN

We have designed a two-compartment recreation facility for the space base. One compartment supports leisure activities such as reading, board games, watching television and movies, etc. The second compartment is designed for sports and exercise; however, it can also be used for certain group activities not associated with sports and exercise. Each of these compartments is discussed below.

Space Base Sports/Exercise Facility

The difficulties of providing for sports activities in the space base were discussed in Chapter IV. These difficulties arise from the 0.3 g field and its orientation. The conclusion reached was that the

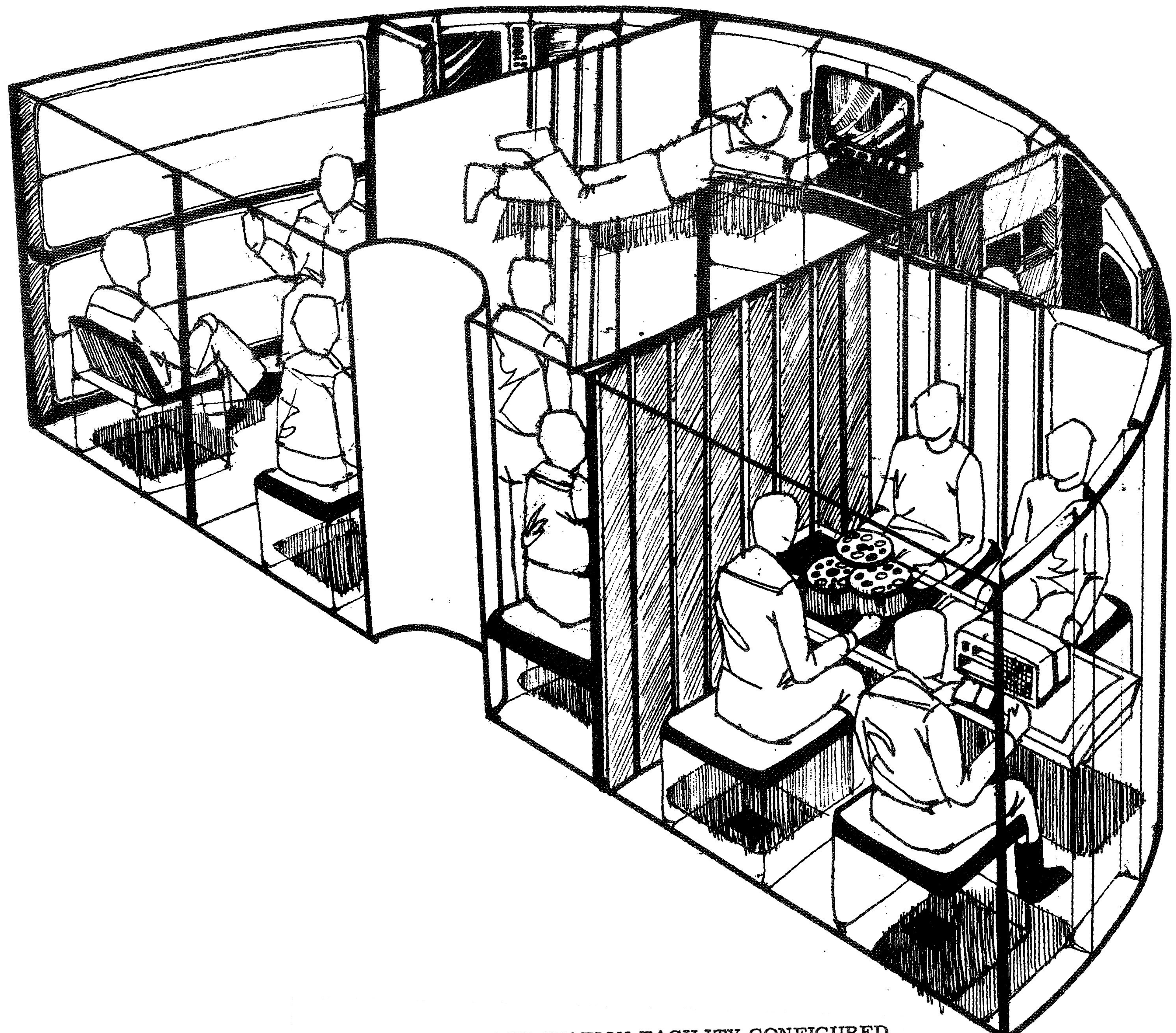


FIGURE 20. SPACE STATION FACILITY CONFIGURED FOR LEISURE ACTIVITIES

dimensions of the facility are incompatible with sports. Indeed, with present limitations in the floor-to-ceiling distance, it is debatable whether any sports equipment at all should be provided.

Figure 21, which shows crewmen engaging in sports, should not be construed as a relaxation of the position taken above. We expect that the crewmen will attempt to engage in sports regardless of the inadequacy of the facilities; therefore, we have attempted to provide for some sports.

The large dimensions of each space base facility (compared to the space station) enables partitioning a compartment so that three types of activities; sports, exercise, and some leisure activities can be undertaken simultaneously. Sports are minimally possible by using nets to partition off a sports area. The spring return nets permit a variety of sports which do not require large volumes of space such as handball or squash. The crew members portrayed in Figure 21 could easily be participating in a game of handball.

The exercise equipment would be stowed behind panels when not in use. The equipment would be that previously described as best suitable for a peripheral heart action training program. The compartment, as designed, could accommodate as many as eighteen exercise stations. This would enable a one hundred man crew to exercise in two hours if the exercise requirement is twenty minutes per crew member.

Some small group leisure activities could also be accommodated in the sports/exercise facility. The ceiling of the facility is made up of triangular-shaped panels which can be deployed into seats as shown in Figure 21. These will accommodate up to ten persons for a variety of suitable activities. Television, movies, lectures, and group discussions could be undertaken in the sports/exercise facility in the event of overflow from the leisure facility.

The sports/exercise facility suggested above can be deployed to permit any part of the facility to be used for any of the above purposes. This design concept is recommended even if our suggestion for a higher ceiling is implemented.

Space Base Leisure Facility

The space base leisure facility is designed to support such activites as reading, watching television, playing cards, personal communication, etc. The facility can be simultaneously employed for a variety of these activities. As in the space station, this capability rests upon the advantages of modular construction, noise control, and the general flexibility gained by employing inflatables wherever possible.

The modular construction is evident in Figure 22. The seats and tables shown form a part of the surface of the wall of the compartment in their stowed configuration. The personal chambers shown on the far wall are similar to those recommended for the space station and are a combination of hard and soft surfaces.

Control of music presentation is provided for by three pieces of equipment, only one of which, the personal chamber, is shown in the accompanying figure. The other two are headsets and room divider screens which are well known solutions to sound control. The screen would be designed to be both deployable and movable. They, and the headsets, could be stowed within the wall when not in use.

The lounging chairs portrayed in Figure 22 have not been previously shown in this report. These chairs are inflatable and could be stowed in a small fraction of their deployed volume. The shape of the deployed chairs is flexible; the angle of the back in the lounging configuration is adjustable.

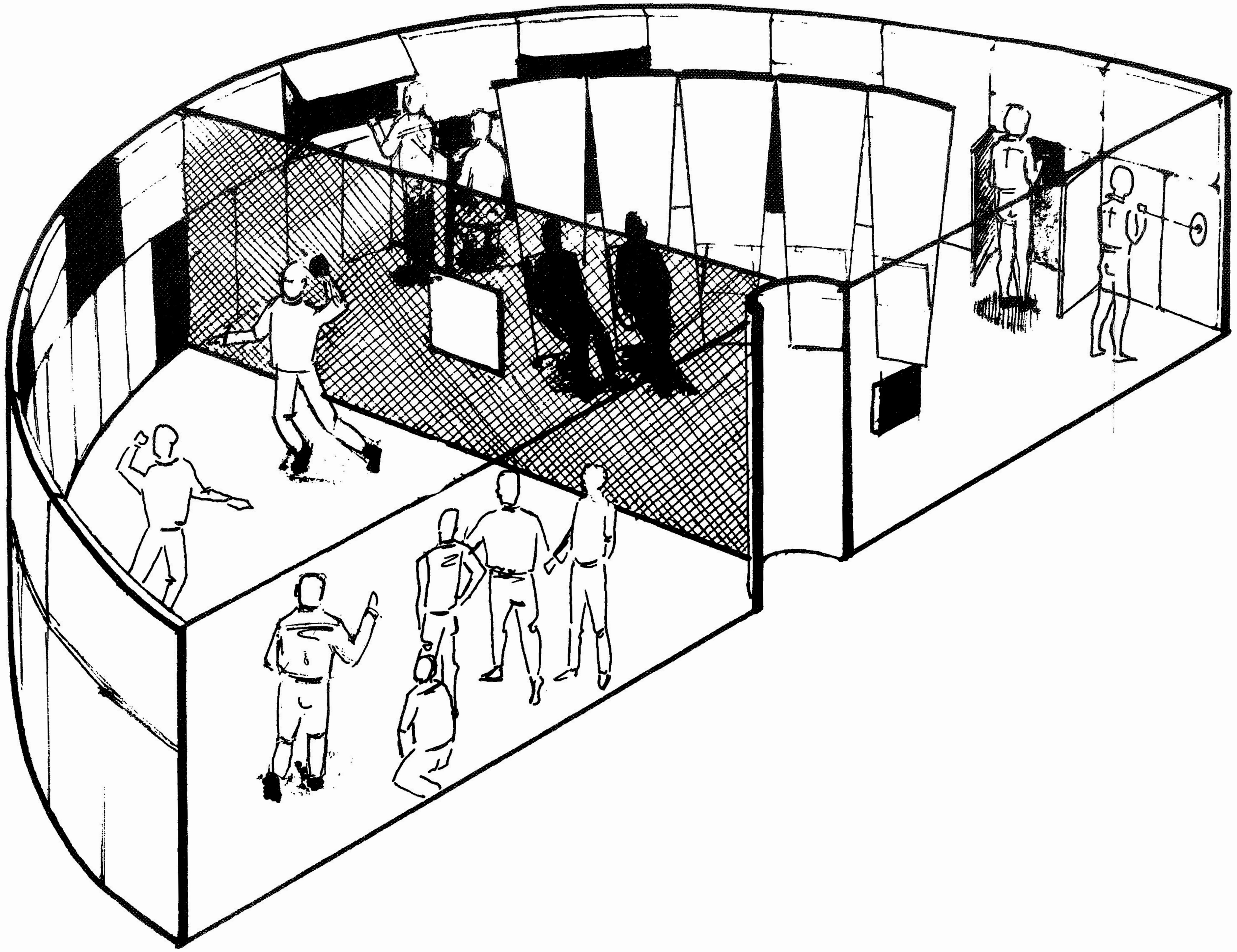


FIGURE 21. SPACE BASE SPORTS AND EXERCISE FACILITY

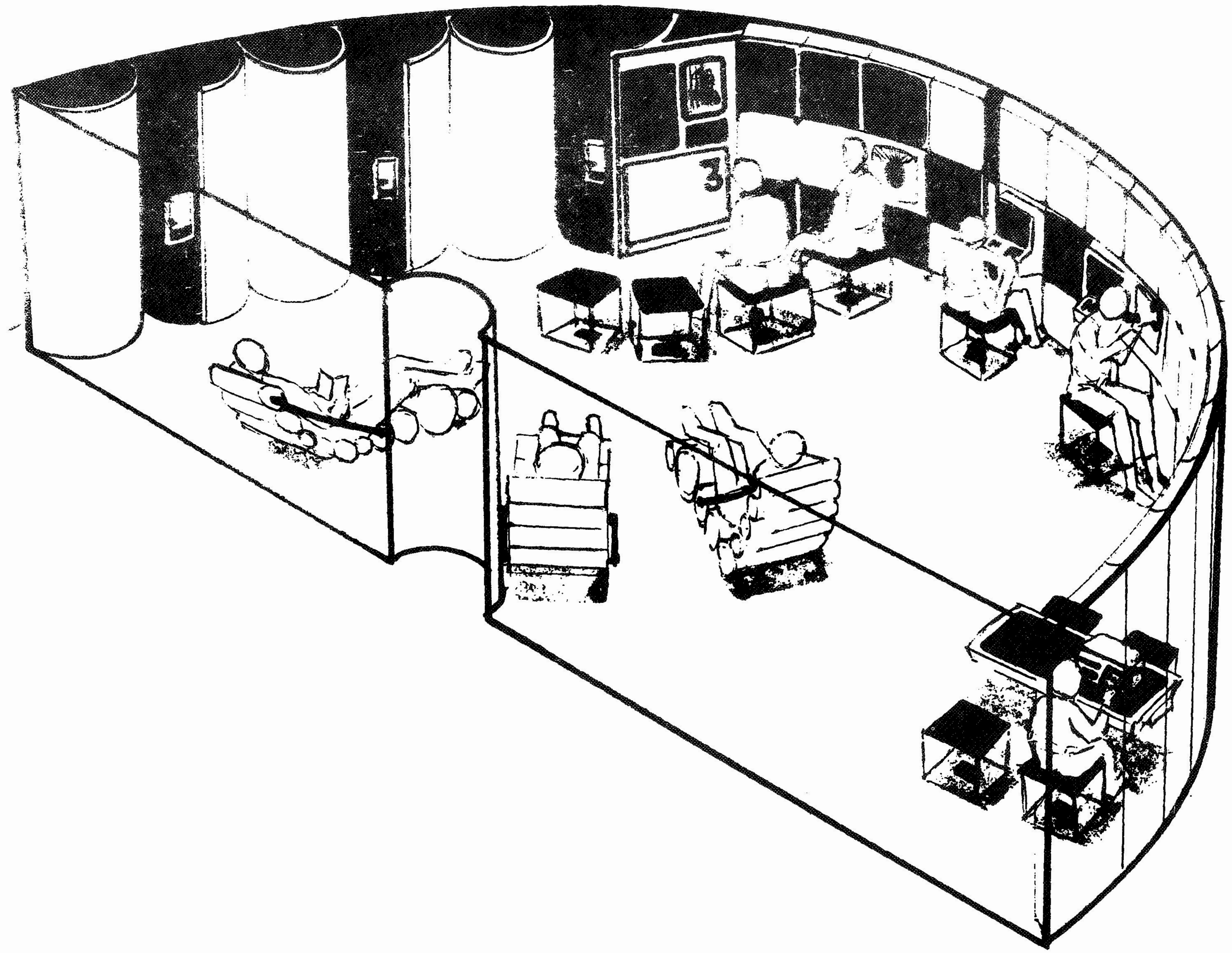


FIGURE 22. SPACE BASE LEISURE FACILITY

With the provisions shown in the accompanying figure, or described in the text, the leisure facility could accommodate about a third of the crew simultaneously. Other crew members could use the sports/ exercise facility. Clearly, however, the entire crew could not be accommodated simultaneously even in the two facilities. Unless larger facilities are made available, some crew members will have to participate in off-duty activities elsewhere (sleeping area, workstation, eating area, etc.).

APPENDIX A

RELATED OFF-DUTY PREFERENCE AND ACTIVITY DATE FROM DOLL AND GUNDERSON (1969) AND EBERHARD (1970)

TABLE 22

MEAN, STANDARD DEVIATION, AND RANK ORDER PREFERENCES OF PRESENT OFF-DUTY ACTIVITIES

	Astronauts (n = 30)			ARPS Pilots (n = 44)			Tactical Fighters (n = 37)			Aerospace Engineers (n = 53)		
Present Off-Duty Activities	Rank	Mean	S.D.	Rank	Mean	S.D.	Rank	Mean	S.D.	Rank	Mean	S.D.
Job Related Activities	1	3.72	1.07	2	3.56	1.01	2	2.94	0.79	11	1.86	1.06
Reading	2	3.63	0.93	3	3.34	0.83	1	3.32	0.92	1	3.30	0.91
Physical Exercises	3	3.37	0.76	4	3.02	0.59	5	2.81	0.74	4	2.59	0.93
Studying or Coursework	5	3.03	1.10	1	3.89	1.04	8	2.49	0.87	6	2.38	1.23
Playing Sports	5	3.03	1.00	6	2.86	0.83	7	2.78	1.07	7	2.36	0.88
Listening to Records, etc.	5	3.03	1.13	7	2.73	0.92	5	2.81	0.81	3	2.64	1.02
Family Activities	7	3.00	1.14	5	2.89	0.84	5	2.81	0.74	2	2.96	0.88
Watching TV, Movies, etc.	8	2.27	0.98	8	2.41	1.13	3	2.84	0.90	5	2.42	0.91
Being Alone	9	2.00	1.02	13	1.73	0.76	14	1.72	0.81	9	2.02	0.91
Technical Writing	10	1.83	1.05	9	1.91	0.96	17	1.46	0.65	18	1.49	0.82
Religious Activities	10	1.83	0.91	10	1.84	0.86	10	1.92	0.98	8	2.19	1.11
Personal Writing	12	1.80	0.55	14	1.64	0.65	12	1.78	0.71	20	1.36	0.65
Resting, Relaxing, or Doing "nothing in particular"	13	1.79	0.82	12	1.75	0.69	11	1.87	0.75	14	1.77	0.75
Eating Snacks	14	1.70	0.70	15	1.57	0.66	13	1.75	0.69	12	1.83	0.94
Model Building, etc.	15	1.57	0.77	11	1.82	0.82	9	1.97	1.04	9	2.02	1.01
Playing Card Games	15	1.57	0.57	16	1.55	0.73	16	1.65	0.72	16	1.72	0.86
Painting, Sculpting, Photography	17	1.50	0.68	17	1.36	0.65	15	1.68	1.06	12	1.83	1.03
Playing Board Games	17	1.50	0.51	19	1.34	0.48	17	1.46	0.65	17	1.66	0.92
Playing Gambling Games	19	1.37	0.61	20	1.27	0.50	20	1.32	0.53	19	1.47	0.82
Playing Musical Instruments or Singing	20	1.30	0.70	18	1.36	0.57	19	1.43	0.65	15	1.76	1.14
Stamp, Coin Collecting	21	1.07	0.37	21	1.07	0.33	21	1.16	0.44	21	1.19	0.52

TABLE 23

MEAN, STANDARD DEVIATION, AND RANK ORDER PREFERENCES OF DESIRED OFF-DUTY TIME EQUIPMENT FOR SPACECRAFT UTILIZATION

Equipment Usage in Spacecraft	Astronauts (n = 30)			ARPS Pilots (n = 44)			Tactical Fighters (n = 37)			Aerospace Engineers (n = 53)		
	Rank	Mean	S.D.	Rank	Mean	S.D.	Rank	Mean	S.D.	Rank	Mean	S.D.
Viewports in Spacecraft	1	4.10	0.92	7	3.14	1.25	1	3.57	0.99	1	3.69	0.88
Physical Exercise Equipment	2	3.83	0.65	1	3.64	0.99	7	3.03	0.99	4	3.28	0.84
Record or Tape Player	2	3.83	1.05	4	3.43	0.95	4	3.16	0.99	5	3.25	1.02
Books	4	3.43	1.00	2	3.57	0.90	2	3.30	1.20	3	3.32	1.03
Sports Equipment	5	3.37	1.07	3	3.50	0.76	6	3.05	0.97	6	3.06	1.06
AM or FM Radio	6	3.33	1.18	5	3.25	1.06	9	2.92	0.95	2	3.42	0.97
Newspapers	7	3.11	1.17	8	3.05	1.08	5	3.11	1.10	7	3.02	1.19
Magazines	8	3.00	0.95	6	3.21	0.98	3	3.22	0.95	8	3.00	0.96
Photo Equipment	9	2.72	1.19	13	2.30	1.03	11	2.58	1.18	10	2.81	1.18
Radio Equipment for Personal Communication	10	2.70	1.09	10	2.82	1.04	10	2.78	1.08	11	2.77	1.12
Television Set	11	2.57	1.10	9	3.00	0.96	8	2.97	0.87	9	2.85	0.89
Writing Supplies	12	2.43	0.90	12	2.55	0.93	12	2.19	0.74	14	2.08	0.98
Playing Cards	13	2.23	1.14	11	2.57	1.00	13	2.16	1.04	13	2.25	1.11
Board Games	14	2.20	0.96	14	2.05	0.86	15	1.95	0.97	12	2.27	1.03
Musical Instruments	15	1.70	0.99	16	1.82	0.95	16	1.84	1.01	16	1.96	1.16
Dice	16	1.67	0.88	18	1.50	0.59	17	1.68	0.85	18	1.35	0.72
Model Building Kits	17	1.50	0.73	14	2.05	1.01	14	2.05	0.91	14	2.08	0.94
Painting/Drawing Supplies	18	1.40	0.62	17	1.73	0.90	17	1.68	0.92	17	1.91	0.93
Stamp, Coin Collecting	19	1.07	0.37	19	1.07	0.33	19	1.27	0.56	19	1.23	0.61

TABLE 24

CORRELATIONS BETWEEN THE ORIGINAL AND THE
TIME ANCHORED SCALES OF OFF-DUTY ACTIVITIES ITEMS

Equipment Usage in Spacecraft	r_{xy}*
Viewports in Spacecraft	.41
Physical Exercise Equipment	.43
Record or Tape Player	.85
Books	.51
Sports Equipment	.79
AM or FM Radio	.68
Newspapers	.57
Magazines	.40
Photo Equipment	.75
Radio Equipment for Personal Communication	.48
Television Set	.31
Writing Supplies	.74
Playing Cards	.92
Board Games	.76
Musical Instrument	.67
Dice	.71
Model Building Kits	.52
Painting/Drawing Supplies	.54
Stamp or Coin Collecting	No Variance

Present Off-Duty Activities	r_{xy}*
Job Related Activities	-.02
Reading	.21
Physical Exercises	.53
Studying or Coursework	.71
Playing Sports	.82
Listening to Records, etc.	.53
Family Activities	.56
Watching TV, movies, etc.	.66
Being Alone	.68
Technical Writing	.24
Religious Activities	.53
Personal Writing	.56
Resting, Relaxing, or Doing "nothing in particular"	.70
Eating Snacks	.48
Model Building, etc.	.53
Playing Card Games	.82
Painting, Sculpting, Photography	.39
Playing Board Games	.69
Playing Gambling Games	.70
Playing Musical Instrument or Singing	.90
Stamp, Coin Collecting	.79

*Based on a sample of twenty subjects.

TABLE 25

HOBBY MEANS AND STANDARD DEVIATIONS
FOR WINTERING-OVER PERSONNEL

Hobby	Civilian (n = 148) Means	S.D.	Technical Administrative (n = 103) Means	S.D.	Seabee (n = 123) Means	S.D.
Models	2.37	.67	2.24	.79	2.35	.78
Radio	2.57	.57	2.30	.83	2.01	.81
Classical music	2.62	.58	2.19	.83	2.02	.85
Motorcycles	1.98	.69	1.81	.82	2.12	.88
Plays and dramas	2.38	.60	2.00	.79	1.68	.77
Popular music	2.37	.59	2.69	.54	2.69	.62
Painting and drawing	2.09	.63	1.90	.79	1.86	.85
Individual sports	2.66	.52	2.70	.56	2.63	.63
Reading magazines	2.57	.55	2.68	.56	2.81	.43
Western-country music	1.82	.65	2.20	.84	2.53	.72
Collecting stamps	1.80	.57	1.58	.67	1.45	.58
Hunting and fishing	2.35	.60	2.51	.70	2.75	.55
Team sports	2.47	.63	2.80	.49	2.72	.56
Repairing things	2.70	.48	2.60	.68	2.90	.32
Reading books	2.82	.40	2.74	.56	2.67	.61
Hiking and camping	2.84	.37	2.68	.61	2.76	.51
Movies	2.31	.56	2.62	.63	2.63	.63
Hot rods	1.97	.59	1.85	.77	2.25	.79
Photography	2.50	.57	2.09	.82	2.22	.78
Cards	2.18	.64	2.37	.82	2.36	.79

From Doll and Gunderson, 1969.

TABLE 26

ACTIVITY MEANS AND STANDARD DEVIATIONS
FOR WINTERING-OVER PERSONNEL (Early)

Activity	Civilians (n = 101) Means	S.D.	Technical Administrative (n = 74) Means	S.D.	Seabee (n = 91) Means	S.D.
Movies	3.83	1.14	4.20	1.10	4.36	.82
Bull session (present job)	3.37	1.04	3.50	1.14	4.06	.97
Bull session (past job)	3.02	1.06	3.43	1.17	3.57	1.15
Bull session (general)	2.87	1.13	2.65	1.27	2.62	1.21
Reading fiction	2.92	1.30	2.60	1.47	2.40	1.37
Reading biography	1.72	.94	1.69	.99	1.74	.85
Reading religious literature	1.98	1.33	1.99	1.29	2.04	1.20
Reading technical magazines	3.13	1.36	2.82	1.38	3.08	1.17
Studying courses	2.74	1.45	2.96	1.45	2.85	1.21
Ham radio	2.56	1.13	2.89	1.31	2.86	1.20
Writing letters	2.60	1.16	2.57	1.44	2.60	1.47
Physical exercise	2.19	1.47	2.37	1.36	1.78	1.20
Painting and drawing	1.81	1.13	2.01	1.37	1.99	1.27
"Happy Hour"	2.24	1.27	2.53	1.33	2.78	1.43
Cards	1.79	1.05	1.97	1.23	2.06	1.18
Chess or checkers	1.80	1.15	1.81	1.25	1.80	1.16
Pool or billiards	2.56	1.49	2.62	1.51	3.06	1.42
Classical music	3.74	1.28	3.23	1.58	3.11	1.51
Popular music	3.56	1.37	3.61	1.43	3.98	1.15
Western-country music	2.54	1.47	3.69	1.27	4.01	1.30

From Doll and Gunderson, 1969

TABLE 27

ACTIVITY MEANS AND STANDARD DEVIATIONS FOR WINTERING-OVER PERSONNEL (Late)

Activity	Civilian (n = 81) Means	S. D.	Technical Administrative (n = 70) Means	S. D.	Seabee (n = 84) Means	S. D.
Movies	4.01	.93	4.16	1.18	4.55	.68
Bull sessions (present job)	3.36	1.15	3.63	1.16	4.11	1.01
Bull sessions (past job)	3.14	1.10	3.73	.99	3.98	.97
Bull sessions (general)	2.90	1.13	2.59	1.27	2.56	1.14
Reading fiction	3.26	1.23	3.20	1.34	2.83	1.19
Reading biography	2.00	1.19	1.86	1.07	1.68	.95
Reading religious literature	1.44	.87	1.40	.81	1.61	.86
Reading technical magazines	3.29	1.21	2.76	1.23	2.88	1.13
Studying courses	2.78	1.46	2.86	1.33	2.87	1.16
Ham radio	2.51	1.22	2.71	1.36	2.38	1.16
Writing letters	1.46	.74	1.73	1.17	1.76	1.08
Physical exercise	2.67	1.58	2.49	1.41	2.04	1.39
Painting and drawing	1.44	.87	1.74	1.11	1.51	.80
"Happy Hour"	2.31	1.06	2.32	1.32	2.87	1.48
Cards	1.80	1.23	2.43	1.28	2.57	1.30
Chess or checkers	2.06	1.38	1.60	.89	1.58	.93
Pool or billiards	1.96	1.15	2.57	1.40	2.74	1.36
Classicaly music	3.54	1.37	2.46	1.38	2.39	1.47
Popular music	3.82	1.20	3.91	1.11	4.05	1.16
Western-country music	2.35	1.37	3.46	1.38	3.84	1.27

From Doll and Gunderson, 1969.

TABLE 28

CORRELATIONS BETWEEN "OVERLAPPING" HOBBY AND LEISURE ACTIVITY ITEMS***

Hobby	Activity	Civilian		Technical Administrative		Seabee	
		(n=100) Early	(n=80) Late	(n=74) Early	(n=70) Late	(n=89) Early	(n=82) Late
Classical music	Classical Music	.30**	.41**	.06	.26*	.16	.18
Popular music	Popular music	.28**	.31**	-.03	-.17	.18	.16
Painting and drawing	Painting and drawing	.20*	.17	.12	.32**	.12	.14
Western-country music	Western-country music	.53**	.34**	.37**	.39**	.30**	.34**
Reading books	Reading fiction	.32*	.04	-.01	.07	.19	.04
Reading books	Reading biographies	.17	.07	.11	.00	.15	.17
Going to movies	Attending movies	.15	.29**	.24*	.22	.26*	.17
Playing cards	Playing cards	.10	.43**	.15	.20	.35**	.19
	Average Correlations	.25	.26	.14	.20	.21	.18

Overall Correlation = .20

* $p \leq .05$

** $p \leq .01$

*** From Doll and Gunderson, 1969.

TABLE 29

MEAN, STANDARD DEVIATION AND RANK ORDER OF THE FREQUENCIES OF PRESENT OFF-DUTY READING MATERIAL USAGE

Activity	Astronauts (n = 30)			ARPS Pilots (n = 44)			Tactical Fighters (n = 37)			Aerospace Engineers (n = 53)		
	Rank	Mean	S. D.	Rank	Mean	S. D.	Rank	Mean	S. D.	Rank	Mean	S. D.
News Magazines (e. g., Time, Newsweek)	1	4.53	0.57	1	4.14	0.80	1	4.11	0.61	1	3.87	0.81
Newspaper	2	4.27	0.69	4a	3.91	0.81	2	3.97	0.73	3	3.70	0.97
Playboy Type Magazines	3	4.07	0.74	5	3.89	0.75	3	3.89	0.74	8.5	3.43	0.89
Technical Magazines (e. g., Scientific American)	4	3.83	0.79	2	3.93	0.63	10	3.08	0.86	2	3.81	0.66
General Interest Magazines (e. g., Look)	5	3.77	0.63	10	3.21	0.88	5	3.73	0.65	6	3.49	0.85
Technical Books, Journals	6	3.70	0.84	8	3.57	0.63	9	3.24	0.90	8.5	3.43	0.82
Comic Strips (e. g., Peanuts, Pogo)	7	3.67	0.96	6	3.68	0.74	7	3.41	0.73	5	3.55	0.91
Historical Novels, Short Stories	8	3.60	0.81	3a	3.91	0.60	4	3.87	0.59	7	3.47	0.78
Biographical Novels, Short Stories	9	3.53	0.57	7	3.61	0.84	8	3.38	0.72	10	3.31	0.76
Science Fiction Novels, Short Stories	10	3.40	1.16	11	3.14	1.11	11	2.81	1.10	11	3.02	1.13
Mysteries, Detective Stories	11	3.13	1.04	12	2.98	0.98	12	2.78	0.95	12	2.85	1.05
Hobby Magazines (e. g., Popular Mechanics)	12	2.83	0.83	9	3.32	0.93	6	3.57	0.84	4	3.59	0.80
Western Novels	13	2.77	0.94	14	2.52	0.88	14	2.60	0.83	14	2.70	0.95
Religious Material	14	2.50	0.86	13	2.75	0.78	13	2.73	0.80	13	2.77	1.15

[a] The rankings are based on the unrounded means.

TABLE 30

MEAN, STANDARD DEVIATION AND RANK ORDER OF THE FREQUENCIES OF PRESENT OFF-DUTY MUSIC USAGE

	Astronauts (n = 30)			ARPS Pilots (n = 44)			Tactical Fighters (n = 37)			Aerospace Engineers (n = 53)		
Activity	Rank	Mean	S.D.	Rank	Mean	S.D.	Rank	Mean	S.D.	Rank	Mean	S.D.
Classical	1	4.17	0.86	3	3.64	1.04	2	3.81	0.89	1	3.66	0.94
Folk	2a	3.97	0.93	1	4.00	0.75	3	3.78	0.90	2	3.43	0.93
Popular	3a	3.97	0.78	2	3.98	0.63	1	4.03	0.65	3	3.40	1.05
Jazz	4	3.53	1.14	4	3.39	1.02	4	3.73	0.90	4	3.34	1.09
Electronic	5	2.74	0.98	5	2.36	0.84	5	2.49	1.01	5	2.37	1.00

[a] The rankings are based on the unrounded means.

TABLE 31

MEAN, STANDARD DEVIATION AND RANK ORDER OF THE FREQUENCIES OF PRESENT OFF-DUTY TV OR RADIO SHOW OR MOVIE CONTENT

	Astronauts (n = 30)			ARPS Pilots (n = 44)			Tactical Fighters (n = 37)			Aerospace Engineers (n = 53)		
Activity	Rank	Mean	S.D.	Rank	Mean	S.D.	Rank	Mean	S.D.	Rank	Mean	S.D.
Sports Events	1	4.27	0.87	2	4.30	0.73	1	4.38	0.76	1	4.15	0.89
News, Weather, Sports Reports	2	4.03	0.56	1	4.32	0.56	2	4.30	0.62	2	4.04	0.71
Educational Shows	3	3.80	0.44	5	3.41	0.84	5.5	3.65	0.68	3	3.85	0.69
Dramas	4	3.53	0.63	6	3.27	0.90	8	3.28	0.85	7	3.26	1.04
Travelogues	5	3.41	0.73	7	3.11	0.97	3	3.84	0.76	5	3.79	1.04
Mystery or Detective Shows	6	3.37	1.00	4	3.46	0.70	4	3.81	0.62	6	3.39	1.05
Comedies	7	3.27	0.94	3	3.77	0.64	5.5	3.65	0.79	4	3.83	0.89
Westerns	8	3.20	0.85	8	2.93	0.87	7	3.62	0.68	8	3.25	1.02
Quiz Shows and Contests	9	1.67	0.76	9	2.18	0.97	9	2.43	0.73	9	1.98	0.93

TABLE 32

MEAN, STANDARD DEVIATION AND RANK ORDER OF THE FREQUENCIES OF USAGE OF PRESENT OFF-DUTY GAMES AND PUZZLES

	Astronauts (n = 30)			ARPS Pilots (n = 44)			Tactical Fighters (n = 37)			Aerospace Engineers (n = 53)		
Activity	Rank	Mean	S.D.	Rank	Mean	S.D.	Rank	Mean	S.D.	Rank	Mean	S.D.
Ping-Pong	1	3.97	0.89	1	3.98	0.63	1	3.81	0.78	1	3.94	0.80
Chess	2	3.80	0.76	5	3.39	0.90	2	3.60	1.12	3	3.57	1.08
Darts	4	3.67	0.61	4	3.46	0.88	6	3.38	0.76	6	3.26	0.68
Pool	4	3.67	0.76	2	3.64	0.84	4	3.49	0.80	2	3.66	0.81
Poker	4	3.67	0.99	7	3.14	1.19	5	3.43	1.19	5	3.49	1.22
Checkers	6	3.60	0.72	6	3.16	0.78	7	3.24	0.90	7	3.08	0.73
Bridge, Canasta, Pinochle	7	3.40	0.89	3	3.55	1.01	3	3.54	1.04	4	3.53	1.14
Scrabble	8	3.23	1.04	8	3.05	0.96	11	2.89	0.81	8	3.02	0.93
Solitiare	9	2.87	0.86	12	2.64	0.94	11	2.89	0.91	10	2.87	1.13
Craps	10	2.80	1.06	11	2.68	1.03	8	3.11	0.91	12	2.62	1.16
Monopoly, Sorry, Clue, Parchesi	11	2.77	0.82	10	2.71	0.77	11	2.89	0.77	11	2.79	0.89
Crossword Puzzles	12	2.70	0.88	9	2.91	1.03	9	3.03	0.93	9	2.93	1.16
Charades, Password, etc.	13	2.37	0.93	13	2.59	0.90	13	2.68	0.88	13	2.43	1.07

TABLE 33

MEAN, STANDARD DEVIATION AND RANK ORDER OF THE FREQUENCIES

OF PRESENT OFF-DUTY SPORTS AND EXERCISING

	Astronauts (n = 30)			ARPS Pilots (n = 44)			Tactical Fighters (n = 37)			Aerospace Engineers (n = 53)		
Activity	Rank	Mean	S. D.	Rank	Mean	S. D.	Rank	Mean	S. D.	Rank	Mean	S. D.
Handball	1	4.63	0.72	2	4.09	0.86	8	3.38	0.95	7	3.29	0.85
Football	2	4.23	0.77	1	4.23	0.68	2	4.24	0.86	1	4.02	0.83
Swimming	3	3.93	0.52	3	3.84	0.71	1	4.27	0.69	2	3.89	0.73
Auto Racing or Horse Racing	4	3.55	1.12	9	3.23	1.05	6	3.51	1.02	10	3.10	1.05
Jogging	5	3.50	1.01	7	3.50	0.85	9	3.19	0.88	6	3.30	0.82
Basketball	6	3.43	0.73	4	3.71	0.93	4	3.70	1.05	3	3.67	0.93
Baseball	7	3.40	0.89	6	3.55	0.85	5	3.60	1.07	4	3.55	0.99
Ice Hockey	8	3.20	0.71	8	3.32	0.83	7	3.43	0.73	8	3.22	0.86
Golf	9	3.17	0.79	5	3.68	1.01	3	3.89	1.02	5	3.50	1.00
Calisthenics	10	2.97	1.03	10	2.98	0.85	10	2.97	0.87	9	3.13	0.86

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